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CHARLES E. SEITZ, President — RAYMOND OLNEY, Secretary-Treasurer

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Economic Aspects of Farm Mechanization[1]

By Arnold P. Yerkes[2]

NO ONE KNOWS when the first farm implement was invented. In fact, we do not even know what the first farm implement was. Since prehistoric man probably harvested wild grains before he learned to plant them for himself, it is most likely that some sharp-edged implement with which to cut the grain was invented before the forerunner of the spade or hoe, but this is mere conjecture.

Regardless of whether the first labor-saving farm implement was a crude sickle or whether it was some kind of digging implement, we know that some ingenious individual adopted it in order to make the work of harvesting or planting easier, to reduce the amount of time he had to spend at the task, or to increase the quantity he could produce.

If this first implement enabled its inventor to plant more seed or harvest more grain in a day than his neighbors could with their hands, it is plain that he could produce enough for his family's needs in fewer days than his neighbors would require, or if he worked the same number of days as they did, he could produce a surplus which he could trade for things which he or his family might desire.

Perhaps even at that early date there was some division of labor and his surplus could be traded for spears or arrows made by someone who was more skillful in this work; perhaps for furs obtained by other men who were more expert trappers. Regardless of what his surplus might be exchanged for, it is easy to understand that the man, who could harvest a greater quantity of food or plant a greater quantity during the available season, enjoyed a real advantage over his neighbors who did not employ their time so effectively.

If in that age bartering was not engaged in, so that there was no need for producing a greater quantity of food than his own family would require, the time he could save from the task of planting or harvesting was available to hunt game, build a more comfortable abode, or be employed in any other manner that he might desire. If bartering was in vogue, it is easy to see that the man who produced the greatest surplus of crops over the needs of his family, could sustain a higher standard of living than his neighbors who had smaller surpluses to exchange for such comforts or luxuries as were available.

It is much easier to visualize the effect of labor-saving equipment in a primitive civilization, before a division of labor had developed appreciably, and before international trade and competition had begun, than in the highly complex civilization existing today. The influences exerted by the first labor-saving implements were fundamental and are still present. But today there are many other influences from the use of labor-saving farm equipment.

It is fairly easy to recognize such influences in a country or a world where practically everyone is engaged in agriculture. It is quite a different matter to trace such influences in a country or a world where there are many industries, trades, and professions such as we now have.

It is due to this fact that we hear and read so many misstatements regarding the effects of labor-saving equipment in agriculture and, for that matter, in other industries as well.

False ideas as to the real effect of machinery in agriculture have a seriously injurious influence upon not only the agricultural industry, but upon our entire national organization. It is plainly important and desirable that the full effects of machinery should be clearly and generally understood and surely no group of men should be more vitally interested in obtaining and disseminating accurate information on this subject than the members of this Society.

Today the fundamental purpose of farm machinery is to reduce the amount of human energy required in producing food, just as in the case of the first farm implement invented. Aside from accomplishing this result, however, it has many other effects. Some of the most obvious are:

1. Making it possible to substitute animal or mechanical power for human muscles
2. Enabling a worker to accomplish more per working hour, or less time spent in producing a given output
3. Improving the quality of work in seedbed preparation, tillage, and harvesting, thus increasing the returns per acre for a given amount of human labor
4. Speeding up the rate at which farm operations can be accomplished, which often makes it possible to produce or save a crop in spite of unfavorable weather conditions
5. Permitting practices of soil conservation and fertility-building which would be impossible without them
6. Making it practicable and profitable to farm low-yielding land, of which there are large acreages in various countries.
7. Making it possible for one worker to produce a

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers held at The Stevens, Chicago, in November 1932.

[2]Editor, "Tractor Farming," International Harvester Company. Mem. A.S.A.E.

greater quantity of crops, thus enabling a small part of the population to produce sufficient food, not only to feed themselves, but those engaged in other industries

8. Eliminating to a great extent the need of transient farm labor for peak periods—to the benefit of the laborer, the farmer, and the farmer's wife.

There are several others which will be discussed later. Those just mentioned are more or less generally recognized. Few people will seriously question any of them. At the same time the full effects of their influence upon the development of this entire nation, both agriculturally and industrially, are not generally appreciated and are difficult to analyze and picture.

It is plain that by reducing the percentage of the population required to produce food, more people can devote their time and energies to the development of industries other than agriculture, and to this fact we owe almost entirely our tremendous national wealth and high standards of living. Yet this release of workers creates an economic problem of large proportions in providing suitable employment in other industries for the workers not required for food production.

A comprehensive discussion of this single problem would demand a great deal more time than is allotted for this entire paper. It might be remarked in passing, however, that to blame farm machinery for this problem is about the same thing as a farmer condemning the sunlight because it makes weeds grow. It is plainly the duty of the farmer to so manage his farm that the sunlight is utilized in growing useful plants, and it is equally the duty of our industrial and political leaders to see that the releasing of workers from food production does not become a curse instead of the blessing it should be if proper management is exercised.

Too many people can see only the effect of labor-saving equipment in eliminating jobs, and fail to recognize the fact that these machines also create innumerable jobs—in most instances far more than they eliminate.

Most people, of course, recognize the fact that the building and distributing of farm machines creates considerable employment in mines, on railroads, in factories, and in retail stores. Also that it is more desirable to have workmen engaged throughout the year manufacturing farm machines than it is to have them employed on the farms during the short peak seasons at work which the machines could just as well do.

WHY AND HOW THE MACHINE CREATES MORE EMPLOYMENT

But this is only a small part of the employment which farm machines create. The fact that farm machines enable a small part of the population to produce its own food and enough for large city populations means that innumerable men must be employed in storing, transporting, processing, and distributing the food produced by these machines. In a country where hand methods are employed in farming, there is no such surplus to be moved from the farms, no elevators are necessary to store the enormous quantities of grain; no cold storage warehouses need be maintained, no huge freight shipments of foodstuffs must be handled, no large flour mills, starch mills, creameries, condenseries, cereal factories, etc., need be constructed or operated, and no extensive system of retail distribution is required.

Yet in this country our farm machines are directly responsible for the tens of thousands of jobs involved in these activities.

In other words, while machines do save man labor in producing farm crops, considerably more on the whole than is required in building and distributing the machines themselves, they are also directly responsible for creating an enormous number of jobs in many different lines. And, as already pointed out, many people entirely overlook these effects.

After the preceding paragraphs were written, there appeared in the November issue of the "New Outlook" an article, entitled "Technocracy," which has caused considerable discussion in many quarters. It is based upon a ten-year study carried on by several engineers in connection with Columbia University.

It points out how machinery is displacing workers in all lines of industry, and makes dire predictions as to the imminent collapse of our entire social and industrial systems because of such technological unemployment. Because of the reputed abilities of the men who conducted the study, many people not only regard their conclusions as unimpeachable authority for the assertion that machinery does create unemployment, but fully expect to see their predictions fulfilled in the immediate future.

Presumptuous as it may be, I venture to challenge the accuracy of some of the statements they make regarding the effects of labor-saving machinery and to doubt the soundness of their conclusions and predictions.

A CHALLENGE TO FALSE STATEMENTS ABOUT FARM MACHINERY

Time will permit but a few quotations and comments thereon. I select this one first: "In agriculture, one man can do in one hour what it required 3,000 hours for him to accomplish in 1840."

That is making some claims for farm machinery which the most eloquent advertising copy-writers and the highest of high-pressure salesmen would never have dared to make, for "incidentally it isn't true," so far as well-informed implement men are aware. It is a matter of ample record that the average farmer of 1840 plowed an acre or so in a day, cradled and bound about an acre of grain in a day, and did other work at proportionate rates. Has anyone here ever heard of a farmer who, single-handed, plowed 3,000 acres in a day, or harvested this area? I doubt it. The farmer who today plows 12 to 15 acres in 10 hours is far above average performance, and harvesting 25 to 30 acres per day per man is certainly better than most farmers would claim to do.

The proportion of 3000 to 1 as quoted is a ridiculous error, and any conclusions based upon such figures must of necessity be worthless. Even the difficulties some engineers are known to have with decimal points will not explain it. Moving the decimal point two places to the left still leaves the proportion far out of line with actual average performance of farm workers in 1932 and 1840.

The next statement I wish to quote is: "Bear in mind that 100 men in modern plants working steadily could produce all the bricks the country needs."

I do not believe there is a single person in this audience who is willing to accept that statement as true. Even if it be granted that one hundred men can operate the machinery which will form and bake bricks fast enough to supply all our needs, how many bricks could this hundred men make if there was not a large force of men procuring and transporting the clay, another large force mining and transporting the fuel for baking, and another group providing the electric power?

It is a very common mistake to give individuals credit for accomplishments which would have been utterly impossible for them without a large amount of assistance and support from others who occupied inconspicuous but nevertheless highly important positions. Everyone is aware of the frequency with which this occurs during the football season. The man who carries the ball is usually given most of the credit, while those who did the important work of opening a gap in the opposing line or running interference are almost entirely ignored. Yet anyone who gives the matter the slightest consideration must realize that the ball carrier alone could do less than nothing.

In every war there has been the same sort of thing. Individuals, companies, and regiments receive the highest commendation for their victories. No war reporter or historian ever thinks of telling about the immense amount of work which had to be performed by the other branches of the service in making these achievements possible.

While the farmer with modern machinery is able to effect a tremendous saving in human labor, behind him is a vast army of workers which has made it possible—through the great array of machines, implements, materials, and services which these workers have produced—for him to achieve greater efficiency and economy in his farming operations, and therefore larger profits. Before any labor-saving machine can save an hour of labor, labor must be expended upon it and wages paid to produce it

Yet we all know that if the intelligence service, the communication service, the ordnance department, the quartermasters' department, and numerous other branches had not done their part well, a victory for the advancing forces would have been impossible. Few people ever stop to think that if the men who manufactured the ammunition had been careless or incompetent and supplied faulty cartridges, defeat instead of victory would have been the result. The same thing is true regarding the manufacture of the guns, large and small.

The point I want to bring out is that in this machine age the accomplishments of the man who operates a given machine, whether it be a gun or a tractor, are by no means due entirely to the individual operator. Behind the farmer who produces a large quantity of high-quality crops is a vast army of unseen workers who make the farmer's achievements possible. These include the men who designed, produced, distributed, and serviced the equipment the farmer uses; the men who pumped, refined, and distributed the fuel and oil for the tractor; the men at the experiment stations who developed the improved varieties of crops; the men who discovered the best treatment of the soil to give high yields; the men who learned how to protect the crops from diseases and insects, and many others.

In other words, our agricultural industry is a decidedly complex organization where many departments and individuals contribute to the final result, just as in a large army.

Incidentally there is one very important point in connection with the use of machinery which was not even mentioned in the article referred to, and I do not recall ever having read about it or heard it mentioned. This is the fact that purchasing any machinery is equivalent to creating jobs and paying wages in advance. This is just as true in the case of farm machines as of any others.

Always, before any so-called "labor-saving" machine "saves" a single hour of labor, labor must be expended and wages paid to produce it. In many cases this is a considerable item. I can cite one specific case where a machine was purchased to perform certain operations on a heavy tractor casting. When installed it displaced six men. Their combined wages amounted to about $10,000 annually. The machine cost $50,000. Most of this went to pay for the labor to produce it. Even if we deduct 20 per cent as profit, taxes, or other overhead (much of which nevertheless creates employment for someone), it still leaves $40,000, which was paid as wages on jobs the machine created before it "saved" a single hour of work. That means it would take four years for that machine, running full time, to save as much labor as it had required to produce it. All the time, however, it was doing better and more accurate work than the old equipment, and if it eventually effected a net saving of labor in producing a tractor, it is reasonable to suppose that at least part of this saving would be passed on to tractor purchasers in a lower price, in the hope that such lower price would increase the volume of sales and incidentally this would mean more work for the entire force of the tractor plant.

The effect of machinery in reducing production costs and thereby increasing the consumption of goods, which in turn means increasing employment through the need for more of such cost-cutting machines, factories to house them, raw materials to supply them, power to operate them, transportation for the raw materials and the finished products, wholesale and retail sales organizations to distribute them, etc., etc., is of tremendous magnitude. The entire automotive industry, which furnishes more jobs than any other single industry in the United States, has developed very largely from this effect.

If automobiles were built by hand methods or old-fashioned shop equipment, they would sell at such high prices that very few people could afford to own them. But because production costs are cut at every turn by labor-saving machines, prices are within reach of millions of people, the output of the industry has grown to an enormous figure, and millions of jobs were created not only within the industry itself, but in the allied industries of oil production, road building, cement and steel manufacture, etc., etc.

It is true that every time an improved machine was installed in an automobile factory there was some displacement of labor at that particular point, but it is ridiculous to look only at this minor labor displacement and ignore the obvious and indisputable fact that the final result of the invention and utilization of all the labor-saving equipment in the automotive industry was to create millions of jobs which would never have existed had it not been for such machinery.

The growth of our printing, engraving, and paper industries, as well as many others, has likewise been due entirely to the introduction of so-called "labor-saving" machinery. The invention of the modern printing press was looked upon by many people of that day as the destroyer of jobs for the small number of people engaged in producing books and manuscripts. Yet today hundreds of thousands of people are employed, not only in operating printing presses, but in producing and transporting the paper, writing and preparing material for publication, transporting and retailing the products of the printing presses, etc., etc.

In other words, by making printed matter cheap and thus creating an enormous market for it, the labor-saving

equipment of the entire publishing industry, while destroying the jobs of a few people, has created a thousand or more jobs for every one destroyed.

It is undoubtedly true that machinery, supplemented by steam and electric power, has, over a long period of years, enabled us to produce sufficient necessities of life for most of our population, and the luxuries of life for a small part of our population, with less human energy, for the eight-hour day has pretty generally replaced the ten-hour day in industry, while on many farms there has been a corresponding decrease in the length of the working day and women and children are found in the field much less than formerly.

I would be willing to admit that with present machinery it might be possible to produce sufficient goods with a six-hour day to maintain a standard of living equal to that prevailing when the eight-hour day first became general. But when this group of "technocrats" make the statement that "the adult population of this nation would have to work only four hours a day for four days a week to supply us with all our material needs," I demand the right to disagree with them, or at least to insist that they furnish me with some means of convincing my wife and children that their "material needs" as they present them to me are largely "immaterial." And I feel sure every married man in this audience will hold a similar view.

I have already spent more time on this subject of labor displacement by machinery than would be warranted were it not for the fact that it is of such current interest. But before leaving it I would like to call attention to the fact that the United States, which employs more machinery than all the rest of the world combined, has for generations not only kept its native-born population quite fully employed but has furnished employment to millions of immigrants who came here from countries where machinery was not so commonly used but where they were unable to obtain either permanent or profitable employment. If machinery actually creates unemployment, these conditions should have been reversed, and unemployed from this country should have been emigrating to countries where machinery was not so generally used. The actual facts, however, seem quite conclusive proof that, whatever may be the real cause or causes of the present depression and widespread unemployment, machinery has not been a major factor.

MECHANIZED FARMING REQUIRES MORE CAPITAL AND MORE LAND

One important aspect of mechanized farming as compared with farming by hand methods is the fact that mechanized farming requires the investment of a relatively large amount of capital in equipment, and at the same time a much larger area of land on which to operate. This is more significant than may appear at first thought. It substantially reduces the number of people in a position to engage in mechanized farming. It involves the need of considerable credit, thereby creating an economic problem of great magnitude.

More important still, any appreciable decrease or increase in the number of mechanized and well-financed farms has a pronounced effect upon the marketable surplus of crops.

The addition of a few hundred efficient mechanized farms has a much greater influence on the marketable surplus of farm crops than will the addition of several thousand farms employing hand methods or even small horse-drawn equipment.

Likewise, the elimination of a few efficient mechanized farms reduces the marketable surplus more than does the elimination of a large number of small, inefficiently operated farms.

The effect of mechanized farming on the marketable surplus of crops, as compared with hand methods, is far greater than is commonly realized. Only on a good soil and with favorable climate can hand methods produce sufficient food for the farming population. Livestock and dairy farming are practically impossible where crops are grown by hand unless considerable areas of pasture are available. It is rather surprising how few people realize that the high percentage of foodstuffs represented by meat, dairy products, and eggs, in this country, is made possible only by the use of machinery in producing low-cost crops. No one can afford to feed hand-grown crops to animals.

FARM MECHANIZATION RESULTS IN HIGHER LAND VALUES

The livestock industry in the United States has been developed partly because of the large areas of grazing land, but principally because of the production of large quantities of low-cost crops by machine methods. The hog, dairy, and poultry industries have developed almost entirely from machine production of low-cost crops.

One influence of farm mechanization which has never received the consideration nor recognition it deserves, is the effect upon land values. The rapid rise in prices of land throughout the Mississippi Valley during the past century has been generally ascribed to the exceptional fertility of the soil, excellent climate, and available markets. These factors, while important, did not explain nor account for the fact that when Iowa land was selling for five or six hundred dollars an acre, equally fertile land in New York, Pennsylvania, and some of the other eastern states, where the climate was fully as favorable, available markets larger, and transportation costs lower, were selling for from fifty to one hundred dollars per acre.

The principal reason Middle West farm lands sold at such a high premium over eastern lands was the fact that farms in the Middle West, averaging considerably larger than those in the East, were much better suited to the efficient use of machinery and the reduction in production costs through extensive use of mechanical equipment far more than offset the other advantages of eastern lands.

If Iowa or Illinois lands had been farmed with the same kinds and sizes of equipment used on New York and Pennsylvania farms, farm lands in Iowa and Illinois would never have been worth as much as farm lands of similar quality in the eastern states.

In other words, the earning power of land, and therefore its actual value, is tremendously influenced by the character of the equipment used in working it. Of equal importance in determining the real value of any farm land is the character of the equipment being used on other land in any part of the world which is in direct competition with it.

Someone once said that Colt in inventing the revolver had made all men equal. What the revolver did for men in personal combat, farm machinery did for men engaged in producing crops from the soil. Just as in a physical encounter without arms the man with the strongest muscles had the best chance of winning, so in tilling the soil with hand tools the man with the strongest back could better provide for his family's needs than the man whose muscles were not so adequate. With hand tools, brains are not much of a factor in farming. With machinery, however, the physique of a farmer has very little influence upon his success. A small man can accomplish just as much as a large one, and a boy or girl who can drive a team or a tractor can accomplish just as much work per day as the brawniest hired hand.

The use of machinery, however, gives a great opportunity for utilizing brains in farming. We might go farther than that and say that the introduction of machinery in farming actually demands a great deal more brains than does farming with hand tools. At the same time, because of the much more extensive and altogether different types of enterprise represented by mechanical farming as compared with hand methods, the possibilities for profits and success through the exercise of keen mental ability compare more than favorably with the possibilities

in other lines of business where the need of real brains has always been recognized.

It need scarcely be pointed out that this change tends to keep a higher percentage of intelligent men on the farms and also to invite more intelligent men into the business from other industries.

Another effect of farm mechanization which has far-reaching results which are not commonly recognized is the great spread it makes in the relative efficiency of individual farmers. This is more serious than may seem apparent at first thought. It increases the handicap of the least efficient farmers, that is, those who are making the least use of labor-saving equipment.

The farmer who uses one-horse implements is obviously at a disadvantage when competing with farmers raising similar crops with two-horse implements. The one-horse farmer is under a still greater handicap when some of his competitors use four or five-horse teams. When some competitors adopt the tractor and complete power equipment, the situation of the one-horse farmer is still more hopeless and, in the case of crops which can be handled entirely with machinery, the inefficiently equipped farmer must give up entirely.

It is true that in the case of cotton we have the complete range from one-horse farmers to tractor farmers using four-row equipment, but this condition exists because, in growing cotton, picking, which is still largely a hand operation, is an important item of cost and the one-mule farmer can pick his crops just as cheaply as the tractor farmer. Yet it is plainly out of the question for the one-mule farmer to receive an income for his year's work which even approaches that of the tractor farmer, and the standards of living of the two men and their families must necessarily correspond to their relative incomes.

Another problem which the mechanization of farming presents is that of maintaining farms in approximately the most suitable sizes to utilize modern equipment most effectively. It is plain that this is a constantly changing problem, for with each improvement or increase in the size of farm machines a change in the size of farm is desirable for best results.

This is not so difficult in newly settled regions where most of the farms still have some unbroken land which can be added to the tilled acreage or where the value of buildings and other improvements is so low as to make it easy and inexpensive to combine two or more farms. In the older farming regions, however, where the value of the improvements is considerable, increasing the size of farms to form efficient units is frequently very difficult and quite expensive, often prohibitively so. This had much to do with preventing eastern farms from being reorganized to compete directly and successfully with the Middle West and West. It was easier to convert small eastern farms to intensive systems—dairying, trucking, fruit growing, etc., in which labor-saving equipment was not such an important factor.

THE FARMER'S INTEREST IN MACHINERY IS ITS EFFECT ON PROFITS

Such sections are frequently affected very seriously by mechanization of farms in other localities where similar crops are produced. The result is that complete changes in the types of farming followed in such sections are sometimes necessary, as just pointed out. As is usually the case where radical changes are compelled by economic pressure, these shifts involve considerable distress to the individual farmer.

It is only natural that the farmer's greatest interest in the effect of machinery is in its effect upon his profits. With him the releasing of labor for other industries, conservation of the soil, and the other factors already touched upon are merely incidental to his endeavors to obtain satisfactory returns from his operations. His primary interest is in increasing the margin of profit between his production cost and selling price per unit of crops, or increasing the quantity of crops he can sell, or both. His surplus crops, the product of his labor, must be exchanged for the products of workers in other industries. His living standards depend upon the result of this exchange.

Plainly, the quantity he has to exchange, the price he receives per unit, and the cost of producing each unit, all affect his net returns.

Now machinery, by increasing his output and cutting his costs per unit, increases his profits and improves his standard of living. At the same time, machinery in the hands of other farmers increases his competition and tends to reduce his selling price, and therefore his profits.

Some people see only the last-mentioned result from machinery, and claim that if farmers used less machinery they would obtain higher prices because of the smaller marketable surplus and would thus make greater profits.

But the individual farmer has no choice in the matter so long as his competitors use modern equipment. And in this he is in no different situation from that of producers in all other industries. Can you picture some well-intentioned person telling Walter P. Chrysler that the trouble with the automobile business is overproduction due to the highly developed shop equipment in the various automobile factories, and recommending to him that he go back to hand methods of production in order to reduce the quantity to be marketed, and obtain greater profits by charging a higher price?

THE FARMER'S CHOICE OF MACHINERY GOVERNED BY COMPETITION

If he could master sufficient courtesy to reply to such a ridiculous suggestion, he would of course point out that it would be suicidal for him to go back to less efficient and higher-cost methods so long as his competitors continue with their present equipment—that they could easily produce all the cars needed and that for him to do anything that would increase his cost per unit would simply mean handing them his share of the business, and bankrupting himself.

Yet just such well-intentioned but unthinking people make similar suggestions to American farmers in all seriousness. But it is disastrous for any producer to refuse to avail himself of any improved, cost-reducing equipment which his competitor has adopted or is likely to adopt.

Some people seem to think that a farmer is entirely free to choose any type or size of equipment that may suit his fancy, or even to use hand methods if he so desires. Of course he can do so if he is not interested in the returns he will receive for his labor. But if he expects to receive a net income equal to that of the more efficient farmers, he doesn't have much choice in selecting his equipment — his competitors practically determine what kind of equipment he must use if he is to compete with them on anything like equal terms.

And it makes no difference whether these competitors are located on adjoining farms, or in some other state, or in the Antipodes, so long as they are producing similar crops and offering them on the same markets.

The fact that our competitors, in any line of business, determine very definitely what our methods and equipment must be, if we are to compete with them on even terms, simply cannot be denied or ignored. Yet some people try to do both. But when they persuade American farmers to follow their advice in this respect they are not only injuring such farmers but the nation as well. The fact that such advice is given with the best of intentions does not remedy nor atone for the damage done.

Some people attempt to justify such advice by claiming that machinery is responsible for the much-talked-of surplus, and therefore is to blame for unprofitably low prices, or will claim that machinery is beneficial and profitable under some particular conditions but quite undesirable at other periods of our business cycles.

It is not within the scope of this paper to discuss whether the "surplus" of either manufactured goods or farm products is due to underconsumption or overproduc-

tion. More than sufficient has already been said on both sides of this question. There is no denying the fact that labor-saving equipment does make it possible to produce a surplus more readily than by hand methods or antiquated tools. But labor-saving machinery in itself does not necessarily bring about a surplus. As a matter of fact, it does not even necessitate an increase in total production.

If it can be shown that there is an actual surplus of foodstuffs in the world, which many deny, and which is not easy to show when there are so many people on short rations, it must be admitted that men and not machines are really responsible for such surplus. And we must go farther than merely pointing to the development of modern equipment to explain why these men invested their money in such equipment and produced crops with them.

In other words, the mere fact that new farm equipment was invented never in itself caused anyone to give up some other business, invest their money in farm machinery, and go to farming.

Yet it is true that many men, a few years ago, did do this very thing, but the reason for their action must be ascribed to something other than the mere desire to own and use labor-saving farm machines. This reason is not hard to find. It was exactly the same reason which has prompted men to invest their money and energies in any other business—the belief that prices for products in that particular industry were sufficiently high to enable an efficient producer to make satisfactory profits.

I am not referring to the recent movement of unemployed men from cities to farms. These people represent a minor influence upon the total crop production, since, for the most part, they use hand methods or small horse-drawn equipment and can produce but little more than their families will consume. They do, of course, reduce the city market for farm crops, and to that extent affect the marketable surplus and tend to depress prices still further.

I am referring to the considerable number of men who were engaged in other lines of business, or who had been so engaged, and who took up farming not through necessity but because it appeared to them to offer exceptional opportunities for easy profits to anyone who would take advantage of modern cost-reducing equipment.

We can all remember a few years ago when farm crops were selling at prices several times their present figure. Even at that time there was a great deal of complaint from many farmers that prices were not high enough to yield them a satisfactory profit. At the same time, many other farmers were admittedly making handsome profits by selling their crops at the prices which their neighbors complained were too low. The difference, of course, was to be found in the relative costs of production. And it can be, and has been, proven that adequate equipment was the greatest factor contributing to the lower costs.

At that time, anyone who dared suggest that prices on farm crops were really high enough or even higher than they should be would quickly have brought down a storm of wrath upon his head.

A few people did venture to suggest that costs of production could be and should be reduced. But farmers, like everyone else, are averse to changing their methods so long as they can avoid doing so, and many of them were undoubtedly led to continue with their old methods and equipment by the mistaken advice already mentioned. The temporary effect of this was to maintain high prices, it is true, but these high prices were obviously more beneficial to the efficient, low-cost producers than to the men who refused to improve their efficiency.

And, inevitably, those prices, which most people are now willing to admit were quite high, invited into the farming business large numbers of men who had made money in other lines of business and who saw what they believed was a golden opportunity to engage in farming on an efficient, low-cost basis and make large profits.

Putting it plainly, such a small percentage of the established farmers were taking advantage of modern labor-saving equipment as it was introduced that strong additional competition was not only invited but encouraged, just as it always is in any other industry under similar conditions.

I think it can be set down as an absolute fact that so long as improvements are made in labor-saving machinery for any industry, there will be many who will employ it; if those already engaged in the industry fail to do so, others will enter the industry and take advantage of it. And the inevitable consequence is that those who do not employ it must suffer.

In conclusion, I wish to state that judgment as to the beneficial or detrimental effects of machinery must be passed on machinery in its entirety. It is not logical nor sound to say that one machine is a curse because it saves labor, while another is a blessing for exactly the same reason. No one can consistently argue that the reaper was an invaluable gift to mankind while the combine is a millstone about our necks, or that the steel plow was a boon while the tractor plow is a calamity. The effects of all are identical, differing only in degree—they are either all good, or they are all bad.

I do not believe we must confess that the men of past generations were more competent in utilizing the improved machines of their day for the benefit of the human race than men of the present generation are in utilizing those of today. We know that there were always people who condemned and opposed new inventions, but there also were always some who had the vision to see the possibilities of such inventions and the courage to convert those possibilities into realities.

And I am confident that the better farmers of today, not only in this country but in other countries, have that same vision, ability, and determination to march constantly onward in the path of progress they have chosen.

An Engineer's Policy Based on Point of View[1]

By Hobart Beresford[2]

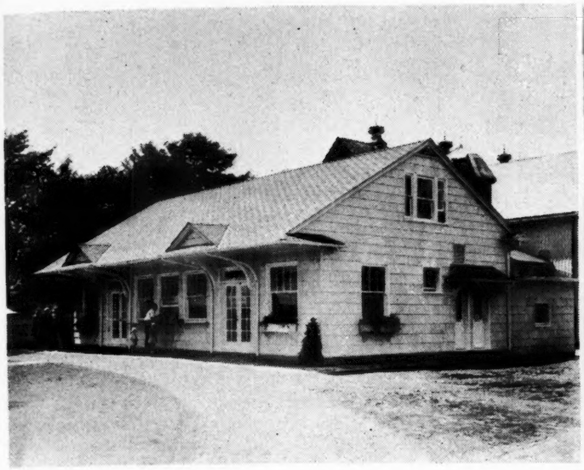
AN ENGINEER'S policy for agriculture is very likely to be influenced by his point of view, which is further influenced by his geographic location. In the Northwest, agricultural development has been dependent largely upon the national policy of land development based on extensive irrigation engineering works and enterprises dependent upon engineering planning and management. Viewing an engineer's policy for agriculture from an area in which the agricultural production far exceeds the demands of the population of the area, lower production costs and improved facilities for transportation necessarily must be coordinated with further development of land and expansion of agricultural enterprise.

An engineer's policy for agriculture should be one of service in planning and managing agricultural enterprises as they now exist with careful consideration of land utilization and the adaptation of production to the competition between individuals and communities. The development of natural resources should be governed by the future as well as by the present economic needs.

The American standard of living, which has been influenced by the engineer's contribution to the mass production of food, shelter, and clothing and the provision of transportation and leisure should be extended to those engaged in agriculture. Better rural homes, including the so-called modern household conveniences, wider distribution of electric service, good roads, etc., should be included in an engineer's policy for agriculture.

[1]A contribution to the discussion of "An Engineer's Policy for Agriculture" at the 26th annual meeting of the American Society of Agricultural Engineers held at Ohio State University, Columbus, in June 1932.

[2]Professor of agricultural engineering, University of Idaho. Mem. A.S.A.E.



An attractive sales and observation room used in connection with the "milking parlor" method of milk production, and (right) a typical "abreast" type of milking stall installation at White Swan farms near Fairview, Pennsylvania

A New Method of Milk Production[1]

By James L. Strahan[2]

IT IS NOT so many years ago since the milkman carried around his forty-quart can and long-handled tin dipper to fill whatever receptacles the housewife left out on the porch steps the night before. I suppose it cost the lives of a great many respectable people to discover that milk produced and distributed as this milk was constituted a menace to public health of no mean proportions, and could not longer be tolerated. Eventually the demand for clean milk became insistent, and because it was practically impossible effectively to reach the original sources of contamination, the cow stables, methods were perfected for processing the milk in bulk at points where it was concentrated before being distributed to the consumer, and at no small cost incident to the development of plants and equipment.

It costs a lot of money to collect the milk, process it, bottle, and distribute it. So much that only a very small part of what the consumer pays for it is left over for the producer. Furthermore, while such milk is perfectly safe so far as the transmission of disease is concerned, yet it is not as good as it should be, nor as it could be. It is a mixture of many different grades from many different sources, and cannot be any better than the average of the lot.

A condition where the public pays plenty for a relatively poor product, where the profit to the distributor is small, and to the producer negligible, if not actually non-existent, is not satisfactory to say the very least. It is such that some change must take place. And we find that a change is taking place.

In the first place, the public is being educated. A new vitamin hardly has time to be christened before "The Saturday Evening Post" gets wind of it and gives it a double page in the advertising section. Ultra-violet radiation is beginning to mean something to the masses. Just what it means would be difficult to tell, but it is very likely that people will shortly be asking for it with their meals. What? No irradiation? Scientific achievements have very definite sales value nowadays when they are appealingly presented. So the public is beginning to believe that cows fed in a certain way with a certain feed will produce milk of a very high nutritional value, and that when it is raw, grade A and certified, it comes nearest to being the perfect natural food that it is possible to produce. If enough of them come to believe this, and begin to demand such a product, what are the farmers going to do about it? They are going to supply the demand, or else relinquish the market to a relatively few live wires with capital to invest, a capacity for hard work, and the kind of intelligence it takes to manage a large-scale business. But whoever undertakes to supply the demand, the changes in method and equipment involved constitute a real challenge to the agricultural engineers.

The old methods are not going to work. New ones must be developed, and are now being developed. The complete solution of all the problems involved are not going to appear all at once. The changes indicated are too revolutionary. The many ramifications of their effects are likely to extend all through the dairy industry. It will take time to complete the picture of the methods, plant, and equipment that is ultimately to change the color of the milk consumed by the majority of our people from blue to yellow. Probably as long as it took to change the contour of the automobile from a buggy without shafts to a streamlined chassis. But I believe we are on our way. The road we are to travel is broadly outlined, and now it is the job of someone to attack and solve the many small problems that develop by the way.

The principal impetus to the latest trend was contributed by Dr. R. R. Graves, of the Bureau of Dairy Industry, U. S. Department of Agriculture. He suggested that a well-known principle of factory management be applied to the milking operation on the farm, namely, "bring the work to the machine." Let us examine the possibilities implied by this suggestion.

At present the machine, either human or mechanical, is taken to the work. A whole system of management seems to be built up around this essential factor. The cow stands in her stall for long periods without exercise. Both she and her stall must be kept clean all the time. Her stable must have smooth walls, concrete floors, steel equipment, large hay storage capacity above. Feeding and cleaning chores have to be adapted to the milking operation to avoid contamination. Cleaning, which must be

[1]Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers held at the Ten Eyck Hotel, Albany, N. Y., in October 1932.

[2]Consulting agricultural engineer. Mem. A.S.A.E.

thorough, and performed preferably twice a day, constitutes an onerous chore that takes time and money. The stable must have facilities for ample drainage, and much water must be used to keep the floors clean. In many places water costs money in the form of power and upkeep for a pumping plant, and furthermore its use in amounts adequate to the maintenance of a proper standard of stable cleanliness, results in a loss of fertilizer value which, if usually unnoted and unmeasured, certainly warrants the serious consideration of the careful husbandman. As a program of production, most of this is generally considered necessary to produce clean milk, although it is by no means always completely followed out.

When the work is brought to the machine, the picture is quite different. Now the cows may be housed in pens, loose, where they are free to move about in comfort. The pen may have an earth floor, covered with bedding, and cleaned out only once in one or two months, as the manure accumulates, thus avoiding major losses of fertilizer elements, and eliminating 90 per cent of the work of cleaning. It is still unsettled as to the proper allowance of floor space to make per cow in the pen, but indications are that a stable will house about as many cows this way as it will in stanchion rows. For convenience in operation, a shorter, wider barn is probably to be preferred in the case of pen housing. If chopped hay is fed, less storage space is needed overhead, and a low gable-roofed barn can replace the high gambrel roof.

From this stable the cow goes by herself to be milked. She reaches a milking room through a passageway designed to keep her in the straight and narrow way, from which she cannot stray, and after being milked she returns to her stable through another passage equally straight. She soon learns the route, what it is all about, and after the first few milkings, requires only to be let out of her pen at milking time to do her part. In a sense she takes over some of the work heretofore performed by her attendant and not only saves him but is better for it herself. She has an occasional change of scene, a good thing for anybody.

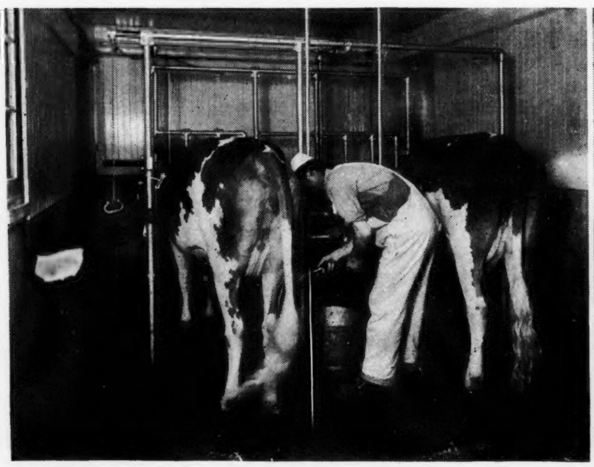
The milking room is comparatively small. It is designed for cleanliness and efficiency. It can be placed on a hospital standard of sanitation, and kept that way to an extent that is practically impossible in the ordinary milking stable, no matter how well cared for the latter may be, and at a much smaller expenditure of money and effort. Equipment is available for drawing the milk, weighing and recording it, conveying it, cooling it, and bottling or otherwise storing it without any possibility of contamination either from human hands or from the air.

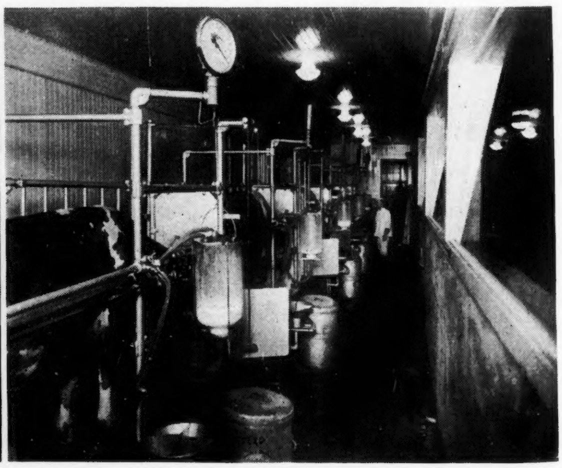
It would seem that as between the two systems, the milking parlor method is a decided improvement. It is likely that, from an economic standpoint, the size of the herd will be the limiting factor controlling its general application. For the smaller herds, during the early stages of the development, the advantages of the newer method will be somewhat less apparent, but for the larger ones there can hardly be any serious question. Just where the line should be drawn is an open question. Development has not yet gone far enough to warrant a definite statement; very likely local conditions, particularly of management, will decide. As for opinion, I have statements from men who have worked with the milking parlor method, to the effect that as few as 20 cows can be handled economically. Others say 50, and a few say 100 cows. Majority opinion places the minimum herd at around 50 cows. However, majority practice indicates a larger herd. The average size of 10 herds on which I have data is 97 cows. As good methods are gradually worked out by experience, and the more general use of equipment brings down its cost of manufacture, it is to be expected that an increasing number of smaller herds will be managed this newer way. One of the principal manufacturers of dairy equipment is working on a new model combine milker that can be placed within the reach of a much larger group of dairymen than has heretofore been able to afford its advantages.

Aside from the Walker-Gordon rotolactor, which is in a class all by itself, there are two types of milking room layouts at present in use. The first contains stalls set side by side, known as the "abreast" type, each pair separated by a railed off space large enough to take the glass jars into which the milk is drawn from the teat cups. Usually one milking unit is installed for each pair of stalls. The cow enters from the rear of the stall and leaves through a gate in the front that is operated by the milker. In the first installations this was a vertically sliding gate, but later swinging gates were developed that had the advantage of directing the cow properly on the return route to her stable. The latest type is one that swings either to the right or left depending upon which direction the cow must take when leaving the milking room.

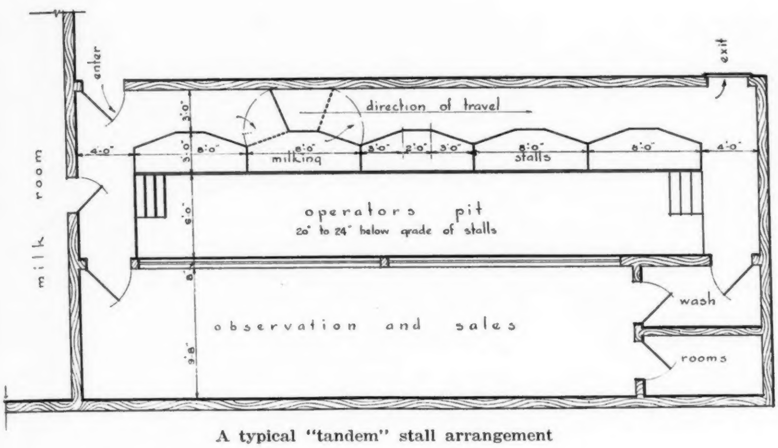
With the abreast type of installation the least time is lost to the machine, for as soon as one cow is finished, the teat cups can be put on the next who is already in the adjacent stall. In some installations, the cows are washed in the milking stalls while waiting to be milked. In one such case, however, the manager reports that he would prefer a separate washing stall outside of the milking room, as an aid in keeping it clean.

The second type is distinguished by the fact that the





(Left) In some installations the cows are washed in separate stalls located outside of the milking room. (Right) A typical "tandem" type of milking stall installation. Both views are from Forge Hill Farm near Newburgh, New York



A typical "tandem" stall arrangement

stalls are placed head to tail, or tandem. Either one or two rows are used, depending upon the size of the herd, and the milker stands in a pit running parallel to the stall row, from 18 to 26 in lower than the milking platform. Because he is on a level with the cows udder when in an erect posture, all bending over to attach the teat cups is eliminated, and the milker's work is to that extent lightened. Each stall has two gates opening on the alley through which the cow enters and leaves the milking room. This is never more than 3 ft wide, and when the rear stall gate is opened it effectively blocks off the alley, leaving the cow no choice but to enter the stall. The front gate, swinging in the opposite direction, clears the route back to the stables, and again the cow has no choice but to follow it. Both gates are latched against the action of a spring which automatically throws them open when released. The milker operates the latch from the pit. Thus, but one man is required to direct the cow once she is in the milking room, draw the milk, weigh and record it, and send it to the releaser in the creamery, from which it goes automatically to the cooler and tank or bottler. In some instances he also feeds the grain ration in the milking stall. There is yet some difference of opinion as to the efficacy of this practice. Difficulties are being encountered, but most of them are being satisfactorily ironed out.

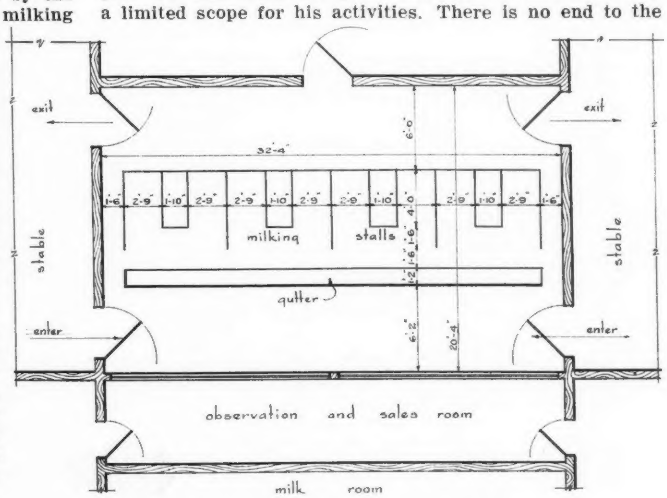
With this method the minimum force required for the milking operation is two men, one to handle the machine, and one to herd and wash the cows. From 40 to 50 cows per hour can be put through the system, whereas by the old method of hand milking or single-unit machine milking two men can handle not more than 12 to 14 cows. Even with double-unit machines in the older milking stables, the same force can handle only from 20 to 25 cows per hour. I have reports from 9 herds ranging in number from 37 to 160 cows, and operating from 3 to 9 units, which show considerable savings in labor costs connected with the milking operation. One outfit was able to save $640.00 per month in wages. Others report saving of 20 and 25 per cent. Several stated that no cash saving was made, inasmuch as the milkers were needed for other farm operations and could not be released, but that they could handle considerably larger herds with the same force.

Perhaps the greatest gain to the industry as a whole lies in the ease with which it is possible to produce a high quality milk. Practically all my reports indicate bacteria counts below 10,000, many below 2,000. True, it requires some time to learn how to use the equipment most effectively, and some who had comparatively high counts at first later brought them down, and have consistently held them there.

For those strategically located near large centers of population, and that is almost anywhere in the East, the advertising value of a well-designed well-maintained milking parlor cannot be overestimated Visitors who once glimpse the possibilities of the process, and taste the product on the spot, become confirmed addicts. In numerous cases, the milk bar in the sales and observation room or along the roadside, has netted very nice returns, certainly enough to justify the overhead investment in what extra building, plate glass, and service is required.

And now, what of the future? In the realm of speculation one man's guess is as good as another's, and the man with the weirdest imagination wins the game. But it is not unreasonable to expect even the smallest herds ultimately to come under the influence of this revolutionary trend. Suppose, for instance, a milking parlor of 3 or 4 units were mounted on a truck and hired out in a community for custom milking. The owner of this outfit might buy the milk in the cow. Milk of a certified grade could be collected from all the little 3, 4, and 6-cow herds for miles around. It would then be unnecessary for all the farmers to rise at four in the morning to milk, and for the milk to stand out on the roadside platform in the blazing sun from 6 o'clock until the collector gets around to pick it up. During this period it would be safe in the cow; and with no damage to her so long as a regular schedule on the route is maintained. And what a reduction in barn work; cleaning reduced to a minimum, manure all saved and kept in best condition to be of greatest fertilizer value, and with less labor than has heretofore been required to waste it. Furthermore this small herd owner could be on hand to check up on the weights and provide for himself data for feeding schedules that in many instances he would not otherwise bother with.

What might happen on the large farm? If the herd is large enough, the machine could be kept busy for from 16 to 24 h a day. One man or group of men would do nothing but milk. Another group nothing but feed. Still another nothing but grow and process the feed. Thus the men would all be specialists, and acquire the personal efficiency that comes only with continued concentration on a single job. On this farm the jack-of-all-trades would find only a limited scope for his activities. There is no end to the



A typical "abreast" stall arrangement

possibilities inherent in this situation. It is no secret that milk factories on this scale are being conceived, nor that one, the Walker-Gordon plant, is already in successful operation.

What of the effect on the distributors? Somebody has mentioned the possibility of using paper cartons for distributing the milk direct from producer to consumer, thus doing away with the necessity for centralization. The cartons could be destroyed after use. No bottle washing, no breakage losses, and maybe no business for the manufacturers of glass bottles. They might have to get into the paper business.

And why not a cap for the carton with a small false compartment containing a little dry ice that would hold the temperature of the milk down during transit, thus enlarging the radius of possible service.

It may all eventually work out that the handling of the milk from the udder to the consumer will be the job of one specialist, and the production of the milk from plant food to udder that of another. Possibly the farmer will be left to confine himself to breeding and feeding, operations that are not usually pleasantly associated with city dining tables, and leaving the handling of the milk, with all the costly precautions against contamination that the public demands, to others who are in better position to observe them. Certainly such a development would relieve the farmer of much expense involved in meeting health requirements, thus reducing his costs, increasing his profits, and releasing him for other more productive efforts and enterprises; and at the same time procure for the public a milk product much better than is at present generally available, and at a lower price.

A Combine Reel for Harvesting Peas[1]

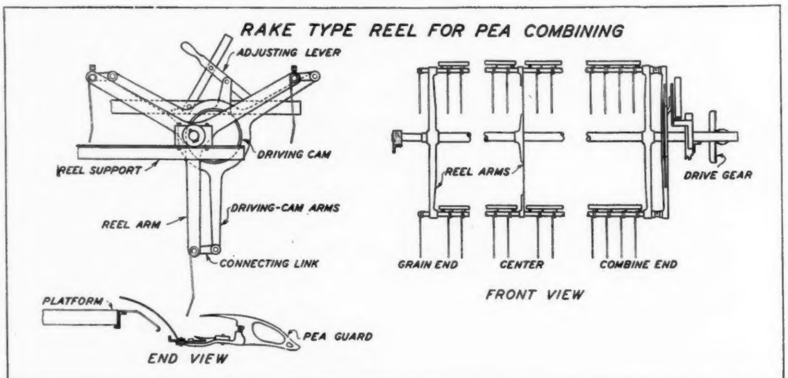
By E. N. Humphrey[2]

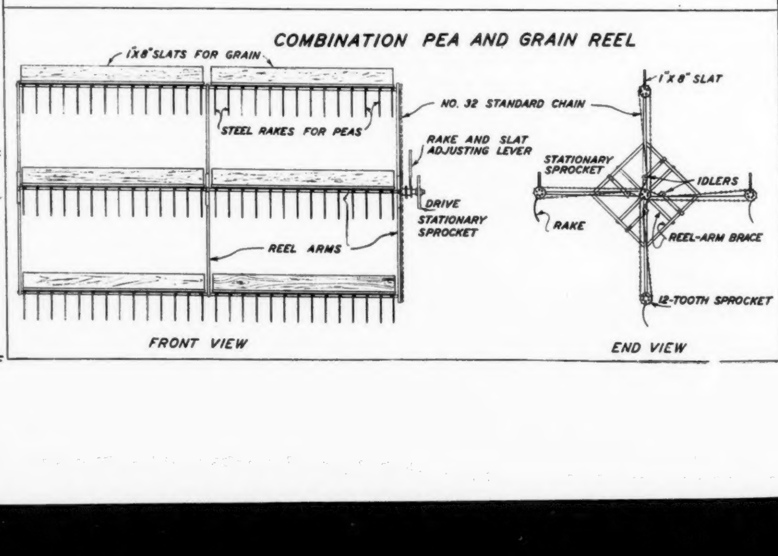
A NEW REEL which promises to materially reduce shatter and field losses in the "combining" of peas was developed this past season (1932) in the agricultural engineering shops at the University of Idaho. Early in the spring, on behalf of a group of pea growers in this region, Mr. Willis L. Crites, of the Sioux City Seed Company, and Mr. Ted Nelson, a local grower, called on the University for assistance in developing a reel that would work satisfactorily for the combining of peas.

The regular grain reel cut down to four blades, which had been used in the past, caused much of the shatter and attendant harvest losses. In the new development it was attempted to design a reel that would aid the movement of the vines onto the header platform and yet not strike the pods with sufficient force to thresh or to carry the vines around on the reel arms or slats.

Mr. Nelson, who had considerable experience with the direct combining of peas, felt that, if the revolving rakes could be taken from the side-delivery hay rake and converted into a combine reel, a much better job of combining would result. Early in June, with the assistance of Mr. Nelson, the author revamped a side-delivery rake reel by increasing the length of the reel arms and rake bars to suit the header platform, using the same eccentric casting for the new reel simply by lengthening the arms and connecting rods. When finished, the mechanism had the appearance of an enlarged side-delivery rake reel mounted on the header platform.

The slow movement and open construction of the new reel allows the use of light-weight materials and permits a clear view of the header platform and cutter bar by the operator. The fact that the tines are dependent, or always pointed downward, is one of the most important improvements over the older type of reel. This action permits the reel to take hold of the vines, to move them gently up the inclined rack to the header platform without any tendency to tear or thresh the peas, and then to withdraw from the vines making a perfect delivery to the platform. Likewise it is possible, through the lever action, to change the eccentric which controls these depending rake tines so that they may be tilted either forward or backward, thus governing the angle at which they enter the vines.

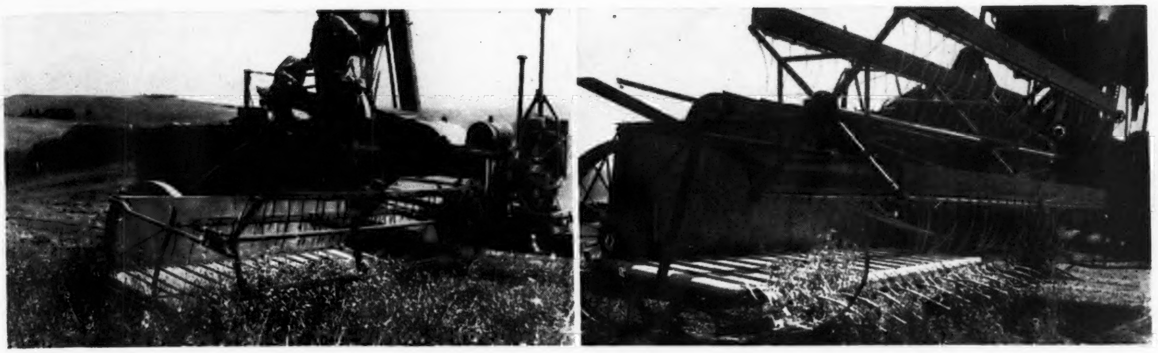




(Above) This drawing shows the construction of the side-delivery rake type reel for combining peas, developed in the agricultural engineering shops at the University of Idaho. (Below) This shows the construction of the combination pea and grain reel developed by Mr. Ed. Love, an Idaho farmer

[1]Approved for publication as a preliminary report by the Director of the Idaho Agricultural Experiment Station, as Research Paper No. 90, and released for first publication in AGRICULTURAL ENGINEERING.

[2]Assistant agricultural engineer, Idaho Agricultural Experiment Station. Student A.S.A.E.



(Left) A view of a combine equipped with a side-delivery rake type reel, showing the method of attachment, and how an unobstructed view of cutter bar is possible with this type of reel. (Right) This is combination slat and rake type of reel showing actuating chains and sprockets

This one feature alone would make the reel worthy of consideration without any other improvement over the older type. Thus far its performance in the field has been very satisfactory and at least two other reels have been constructed and are in operation. One operator who last year lost 685 lb of peas per acre with a harvested yield of 966 lb, reduced the loss to 180 lb this year with the same harvested yield of 966 lb per acre, or only 25 per cent of the previous loss figured on the total yearly production.

During the past spring another reel using practically the same principle was developed by Mr. Ed. Love, a farmer of this region. In it the rake tines are likewise dependent and can be adjusted to any angle or turned completely over, so that the same reel may be used for peas and wheat merely by having a combination rake and reel slat using the rake tines in the peas and the reel slat in the wheat. The reel is well adapted to use in grain that has gone down under action of wind or rank growing conditions, because it can be so adjusted that the curved rakes will reach down into the fallen grain and lift it ahead of the sickle. The activating mechanism of the reel consists of a stationary sprocket mounted on the drive end at the center of the reel around the shaft. Small sprocket wheels with the same diameter as the center sprocket are placed at the end of each blade. A chain runs over the center sprocket to the blades diametrically opposite. Thus a four-blade reel requires two chains that work side by side with sufficient clearance to pass on the center sprocket wheel. As the reel revolves the blades revolve at the same time which maintains the rake tines in parallel planes.

The Economic Control of Insects[1]

By W. C. Krueger[2]

FROM the beginning of history mankind has been confronted with the problem of insect control. Today his efforts are represented in the annual expenditure of millions of dollars and a ceaseless search for new and more effective controls. Concentration of grain, fruit, and vegetable areas, and extensive cultural practices have apparently aggravated the situation, resulting in greater insect injury and the adaptation of what were formerly harmless species to new hosts of economic importance.

Methods of insect control fall into four general groups, namely, development of crop resistance, control by parasites, by chemicals, and by mechanical means. The engineer's interest has naturally been largely with the mechanical equipment for control. To this class has recently been added the powerful weapon of electric energy. Already a great amount of work and study has been devoted to this angle of control and to merely summarize existing information would extend these remarks unduly. Therefore, we will confine ourselves to a basic outline of these new methods of control.

The first consideration in a review of such methods is that we must successfully influence the behavior and movement of the insect. To date we are limited to three effects—attraction, repulsion, enervation. Electric energy has so far been applied in at least three forms—(1) light of varied wave lengths and spectrum, (2) high-frequency, high-tension waves, and (3) supersonic waves. Repulsion is effective in protecting limited areas; enervation inhibits egg laying or mechanical injury by modifying behaviorism; attraction eliminates the insect from the picture, provided that means are taken for extermination.

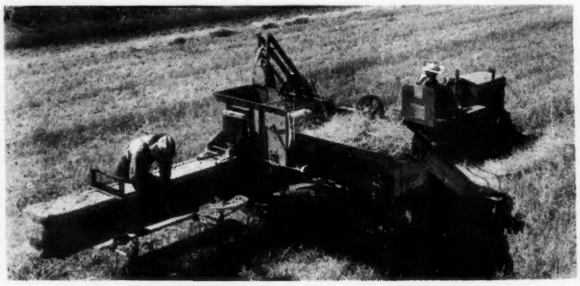
If the electric control method is based on the value of attraction, some means for extermination must be included and associated with the process. Basically there are three methods for doing this: by chemicals, either liquid or gas; by mechanical means such as traps, and by electric energy applied either directly to electrocute the insect or indirectly by means of high-frequency, high-tension waves which induce a lethal fever in the insect through their action on the colosterol, an organic component of all insect nervous systems.

Methods of attraction and extermination are generally used in combination, examples of which are a light with or without bait and a trap; light with a suction fan and trap; light with or without bait and electrocuting wires; bait with or without fan and the lethal grid; bait with or without fan and the trap.

Any approach to this problem of insect control by means of electric energy must be based on some such analysis as has just been given. I feel that by considering all of the factors and balancing them according to their value and association the engineer can best succeed in his experiments. The choice of method or tools depends essentially upon economic factors. We are in direct competition, even though it is cooperative, with the chemist, the entomologist, and the agronomist in this field of insect-control work. The ultimate choice of any specific method will be determined by balancing its effectiveness against the cost.

[1]Abstract of paper presented at a session of the Rural Electric Division of the American Society of Agricultural Engineers during the 26th annual meeting of the Society held at Ohio State University, Columbus, in June 1932.

[2]Agricultural engineer, New Jersey State Agricultural College.



(Left) The combine baler used to reclaim straw from windrows left by the "combine." (Right) In this picture is shown a "combine" equipped with an extension carrier which feeds the straw direct to the baler hauled alongside the combine

Handling Straw from the Combine[1]

By Frank P. Hanson[2]

THE ADVANTAGES of harvesting soybeans with the combine were responsible to a large extent for the introduction of such machines east of the Missouri and Mississippi rivers, particularly in Illinois, Indiana, Ohio, and Iowa. The first combine was used to harvest soybeans in Illinois in 1924, but it was not long before farmers became acquainted with the advantages of using the combine for harvesting other crops. It was after the combine began to be used in numbers for harvesting oats and wheat east of the Missouri and Mississippi rivers that there developed a real demand for saving the straw from combines. Farmers want to reclaim straw for feed or bedding, or to sell. Generally speaking, the greatest demand for straw is for bedding.

Although the demand for straw is usually greatest in the eastern states, during seasons of drought there will be some demand for saving straw in the wheat belt. Because of the lack of moisture in parts of North and South Dakota and Montana last year, resulting in a short crop of feed, there were more calls than usual from farmers owning combines for information concerning the saving of straw.

Since some farmers in the eastern states save little or no straw a considerable number of combines are now being used. It has been the farmer who has wanted to save a large amount of straw each year, who has not used the combine for harvesting his crops, or, if he has used the combine, he has followed some practice of saving or securing straw to take care of his needs.

Last year the Committee on Combine Development found, as a result of a questionnaire sent to 129 combine operators and 100 county agents in Iowa, to the agricultural engineering and agronomy departments of the land-grant colleges, and to the sales and engineering departments of fifteen combine manufacturers, that of all the combine problems worthy of intensive research, as advanced by the people who returned questionnaires, the lack of well-developed and efficient means of saving the straw stood first in importance with 61 replies. Of these, 12 were from Iowa combine operators, 3 from manufacturers' sales departments, 4 from manufacturers' engineering departments, 4 from western agricultural engineering departments, 10 from eastern agricultural engineering departments, 4 from western agronomy departments, 6 from eastern agronomy departments, and 18 from Iowa county agents. High moisture content of grain was checked by 57 to stand second in importance of problems worthy of intensive research.

In U.S.D.A. Bulletin No. 244, entitled "Harvesting Small Grain, Soybeans and Clover in the Corn Belt with Combines and Binders," this statement will be found: "Farmers consider that the chief disadvantage of combine harvesting in Illinois and Indiana is the lack of straw for feed and bedding." Also, in Indiana Bulletin No. 349, entitled "The Adaptability of the Combine to Indiana Farms," this statement is found: "Very few combine owners have reclaimed straw, for most of them had old stacks or could buy straw cheaply from their neighbors. In the few cases where straw has been reclaimed the cost of reclaiming has been approximately $2.00 a ton placed in the barn."

Several years ago I assisted a large dairyman in the corn belt to fit a combine into his farming operations. This farmer was particularly concerned about saving straw because of his dairy herd, and he finally said that, if an economical means of saving straw could be found, he wanted a combine. It was only after considerable difficulty that some cost figures concerning the saving of straw were secured and submitted to this dairyman. The data was apparently convincing because he purchased a combine. After he had stressed so much the importance of saving straw, and held up the purchase of a combine until a method of saving straw had been presented to him, one would naturally have expected that he would have saved a considerable acreage of straw. On the other hand, he did not reclaim any straw from the combine. He purchased straw from a neighbor, paying $1.00 per ton.

Until combines are used in greater numbers, many farmers will, of course, be able to purchase straw, but when the combine is more universally used straw piles made by stationary threshing machines will become less numerous, and for this reason we may assume that the demand for saving straw from combines will increase.

This year's Committee on Combine Development met in Chicago last fall and outlined a program of work in connection with which I was asked to make a report on methods of saving straw from combines.

Let us keep in mind that the object of this report is to cover methods of saving straw, and not necessarily the cost of saving straw by various methods; the value of various kinds of straw; the yields of various kinds of straw in different territories; the need of saving straw; the kinds of straw which may be saved, or straw substitutes. Other members of the Committee on Combine Development are now making special studies of some of these items.

As a result of my own experience in extending the use of the combine, particularly in the corn belt, the problem of saving straw from combines has been considered many times. In addition to my own experience, considerable

[1]Paper presented at a session of the Power and Machinery Division of the American Society of Agricultural Engineers during the 26th annual meeting of the Society held at Ohio State University, Columbus, in June 1932. A contribution of the Committee on Combine Development.

[2]Agricultural engineer, Caterpillar Tractor Co. Mem. A.S.A.E.

correspondence has been carried on with the college agricultural engineering departments, combine manufacturers, and combine owners to get the latest information on all methods now being used to save straw.

All the ways known to have been used in saving straw from combines, can be roughly divided into seven methods.

In the first place, let us consider handling straw after it has been left in windrows by a combine. There are at least six fairly distinct ways that straw can be handled from windrows. First, it can be bunched with a dump rake and loaded on hay racks by hand, or loaded on hay racks direct from the windrows with hay loaders and then unloaded with slings or grapple forks. Although some straw is now being saved, particularly with the use of hay loaders and slings, some of the farmers object to handling straw any of these ways, because the dump rake may pick up loose trash, and straw is usually hard to handle with forks on account of a so-called "slickness" and shortness.

One farmer in northern Illinois used a hay loader and slings until he tried and found more satisfactory the scheme of using an open-back basket type rack, a hay loader and a blower at his barn. His hay rack has high front and sides with an open back, and he has found that one man can load a considerable amount of straw with the hay loader without a great amount of effort. He permits the hay loader to fill up the basket rack without making much of an attempt to load or pack the straw. In fact, he is not anxious to pack the straw because it is unloaded by pushing it off the back of the hay rack into a large blower, which elevates the straw into the barn. The blower came from a discarded threshing machine and cost about $10.00 to assemble so that it could be used for elevating the straw.

This farmer says that he can now get clean barley straw without the objectionable beards and chaff. He advances another argument in favor of this method of saving straw, in that no chaff and beards are blown into the barn to stick against the shingles and sheathing. He says he has noticed that, where straw with chaff and beards are blown into barns, a considerable amount of chaff and beards will stick to the shingles and sheathing and collect moisture breathed by livestock, and because of this layer of wet chaff and beards there is a tendency for the roof materials to rot out on the inside of the barn.

A plan similar to the above is to chop the straw and then blow it into a barn. It has been found that chopped straw will pack so that a greater tonnage can be stored in a given space, and that it is sometimes preferred over ordinary straw for bedding. For instance, when chopped straw is used for bedding dairy cattle, the animals do not drag the straw so easily into the gutter with their feet. It is ordinarily estimated that chopped hay will occupy but 60 per cent of the space required for loose hay.

A third method of saving straw from windrows is by the use of the sweep rake and stacker. The use of this method, like some of the others, depends to a large extent upon the availability and cost of such equipment. Stackers and sweep rakes are not very numerous in the corn belt at the present time.

A fourth method of handling straw from windrows is by the use of a sweep rake and a baler. Balers are distributed through the corn belt, and it has been found that straw can be baled in the field at a reasonable expense. It is reported that a canning company in Illinois has reclaimed straw from a combine with a sweep rake and baler at a cost of $1.50 per ton.

The combine baler is another method of reclaiming straw from windrows. This baler is made so that it can be used for baling from stacks, shocks, or barn. At least two companies are now manufacturing such machines.

The sixth method of saving straw from windrows is similar to the last one, in that it applies the use of a power baler and hay loader combination. This latter unit makes possible the use of present power balers and hay loaders, but does not give as compact a unit, or have other advantages that are found in the combine baler.

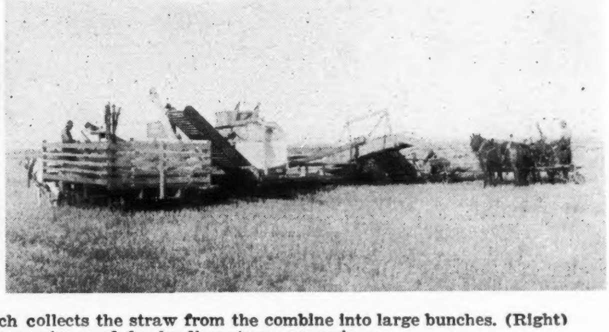
Some of the advantages of reclaiming straw from windrows compared to other methods are:

1. No extra attachments are needed on combine to place straw in windrows
2. No attention of combine operator is required to make windrows
3. Straw placed in windrows by a combine is generally carried by stubble so that it dries out easily and quickly after being rain soaked
4. Beards, chaff, and waste material can be kept out of the straw
5. Extra equipment will not be needed on many farms to reclaim windrowed straw
6. Cut or baled straw can be stored in a much smaller space
7. Straw is usually baled if sold
8. Straw bales better after it weathers a little because it loses "slickness."

A few important facts to keep in mind when reclaiming straw from windrows are:

1. Chaff or light grain cannot be saved without using special equipment
2. Light, brittle, or short straw may fall to the ground and be more difficult to pick up
3. When straw is light, time and expense may be saved by bunching or using other methods of concentrating straw
4. Some of the equipment used to reclaim straw from windrows is costly for small acreages
5. There is a possibility of losing wires in field when baling, to cause trouble with subsequent field operations
6. Wire is an added cost when baling straw
7. Small combines make small windrows. A side-delivery rake pulled behind a combine to make larger windrows did not work well when turning.

The second main method of handling straw from combines is to reclaim the straw after it has been bunched with standard combine bunchers. Combines can be easily



(Left) This is a trailer type of loose straw buncher which collects the straw from the combine into large bunches. (Right) A side-mounted extension straw carrier used for loading straw on racks

equipped with bunchers which will place approximately 75 lb of straw in each bunch. It is not a difficult job to haul, burn, or bale the straw after it has been bunched. On the other hand, the use to be made of the straw will determine to a certain extent the feasibility of windrowing or bunching it. Bunched straw, repeatedly watersoaked, can result in a certain amount of spoilage. This will be a greater disadvantage if the straw is to be used for feed or sold, than if used for bedding.

A sweep rake and stacker can be used for reclaiming bunched straw. Ordinarily the cost should be somewhat less than using the sweep rake and stacker for reclaiming windrowed straw because less time would be required to collect the straw.

Another way to reclaim bunched straw is to use the sweep rake and a baler. Again, the cost should be somewhat less than for windrowed straw because of the time saved in collecting the straw at the baler.

A third way of reclaiming bunched straw is to load it by hand on hay racks and unload it with slings or grapple forks.

U.S.D.A. Bulletin No. 244, reports that of 107 combines used in Illinois and Indiana, only 7 were equipped with straw dumps, whereas 105 were equipped with straw spreaders. The larger number of straw spreaders can probably be accounted for by the fact that a large percentage of these combines are undoubtedly being used for harvesting soybeans.

Some of the advantages of reclaiming straw from bunches compared to other methods are:

1. Chaff and light grain can be saved with or separated from straw
2. A larger percentage of light, brittle, and short straw can be saved when bunched than when windrowed
3. In light straw the concentration in bunches will save time in reclaiming
4. May not need extra equipment to reclaim straw
5. Store in smaller space when baled
6. Straw is generally baled when sold.

A few important facts to keep in mind when reclaiming straw from bunches are:

1. Water soaked bunches may dry slowly and cause some spoilage
2. An extra attachment for the combine is needed to bunch straw
3. A straw buncher requires some attention of the combine operator
4. Chaff, dirt, etc., can not be separated from straw the same as when the straw is windrowed
5. Extra equipment may be needed to reclaim straw from bunches
6. Cost of wire when baling.

THIRD METHOD OF SAVING STRAW

The third general method of saving straw from combines is to cut the straw high with the combine so that the stubble can be mowed and handled the same as hay. There are only a few reports to show that this method has actually been used. Data secured in Indiana indicates that this method of saving straw is rather costly. This method has the following advantages:

1. A larger percentage of straw can be saved
2. Sometimes the grain can be cut higher so that a larger acreage can be combined each day
3. Permits removal of old stubble for clean hay crop the following year.

A few points to keep in mind when considering this method are:

1. Waste material on the ground may get mixed with the straw
2. Extra equipment to mow and concentrate the straw will be needed
3. Straw will be cut up.

The fourth general method of saving straw is to thresh barged, stacked, or bundled grain in a feed lot or field with the combine. In this case the combine is used much the same as a stationary thresher. Barged grain may be fed into a combine by making slight alterations on the standard combine header or pick-up unit. If grain has been cut with a binder, it is necessary to cut the bands, and most of this has been done by hand. Some farmers in the corn belt are opening their grain fields by cutting one or two rounds with binders. They do this in order to make it easier to start the combines. The bundled grain on the outside of the fields is then fed into the combines by hand.

Where the combine may be used for stationary threshing, an extension straw carrier will simplify the handling of the straw. Extension straw carriers, 18 ft long, are now available, and make it possible to make good sized stacks without moving the combine.

When the combine is used to thresh barged grain the straw will be left in piles.

COMBINES IN STATIONARY THRESHING

It is possible that there will be an increased use by corn belt farmers of combines for stationary threshing. Let us consider, for instance, a farmer raising soybeans, oats, and wheat. Practically all of the soybeans are combined direct and the straw is scattered with a straw scatterer. Generally speaking, the wheat will also be combined direct, but the straw will sometimes be saved. On the other hand, this farmer may not wish to combine his oats direct. Because of the fact that he wants to save some straw, his oats are inclined to shatter, or not to ripen uniformly; or, the oats having been seeded to clover, particularly sweet clover, he may prefer cutting the oats with a binder and then threshing with his combine. The acreage of oats will, of course, be but a smaller percentage of his total acreage which can be combined, and he will find it an advantage to use his combine to thresh his oats rather than use a custom threshing machine.

If the combine is used to thresh barged, stacked, or bundled grain in a field or feed lot, the straw will be concentrated in large piles. All the advantages of combining direct, windrowing, barging, or handling the grain may now be secured with the combine. When grain is threshed from stacks or bundles with a combine, some extra equipment will be needed on the combine, and there will be extra costs of handling grain if it is brought to the combine either when barged or bundled.

The fifth general method of saving straw from the combine is with the use of an extension carrier. The extension carrier makes it possible to load the straw on racks. Several combine manufacturers now make such carriers. However, information which I have been able to secure would indicate that but few of such extension carriers have been sold. An extension carrier will also permit feeding directly into a baler, but it was found that the expense, the dust and chaff, and the danger of leaving baling wire in the field were considered as disadvantages. The extension straw carrier furnishes the possibility of mounting on small combines, such as more generally used in the eastern states, so that two windrows may be placed together, as a result of being able to swing the extension carrier to the right and left. It is understood that such a scheme was tried out in Virginia.

The use of an extension carrier makes possible the following advantages:

1. Straw can be loaded into racks or barges
2. It is possible to feed straw direct into balers
3. A swinging carrier will permit concentrating two windrows into one
4. Chaff and light grain can be saved.

A few facts concerning the use of extension carriers should be kept in mind:

1. Extra equipment will be needed for combine
2. Extension carrier requires some attention of combine operator
3. Ordinarily too dirty to operate baler attached to rear of combine

(Continued on page 323)

The Ventilation of Animal Shelters[1]

By F. L. Fairbanks[2]

THE agricultural engineer in working on the problem of ventilation has to deal with the animal husbandman and the veterinarian, as well as the dairyman, or the poultryman, or the sheepman, or the hog breeder. There are many types of shelters for each kind of farm animal to be ventilated, of which the important at the moment are the dairy stable, bull barn, calf barn, maternity barn, beef cattle barn, horse barn, sheep barn, hog barn, poultry laying house, poultry battery laying house, poultry brooder house, poultry battery brooder house, poultry fattening house, and poultry incubator room.

For each of these types of shelters there are many variations in the design of each type. Any one or all of these types of shelters are in different climatic zones, and the climate common to the various zones very greatly influences the ventilation problem.

What is ventilation as we know it now? It is the continuous combining and control of the temperature, the humidity and the air movement within a ventilated space in such a manner or combination that the occupants of the ventilated space are comfortable while performing their normal functions as related to the particular species.

[1]Paper presented at a joint session of the Structures Division and the Rural Electric Division of the American Society of Agricultural Engineers during the 26th annual meeting of the Society held at Ohio State University, Columbus, in June 1932.

[2]Assistant professor of agricultural engineering, Cornell University. Mem. A.S.A.E.

In other words, it is, first, the continuous combination of the factors of heat, humidity, and air movement within the space (convection currents); second, the admission of sufficient fresh air for the needs of the animals found in the ventilated space, and third, the removal of foul odors, vitiated air, dust, and excess moisture. The second and third factors constitute the air flow into and out of the space.

Let us take the dairy stable as an example to which to apply this conception. We have generally in the colder climates well-built stables with warm walls and ceiling. The cows are stanchioned in rows in the barn and there is approximately 1000 lb of live weight for every 600 to 700 cu ft of space in the stable. Plenty of heat to work with and warm walls.

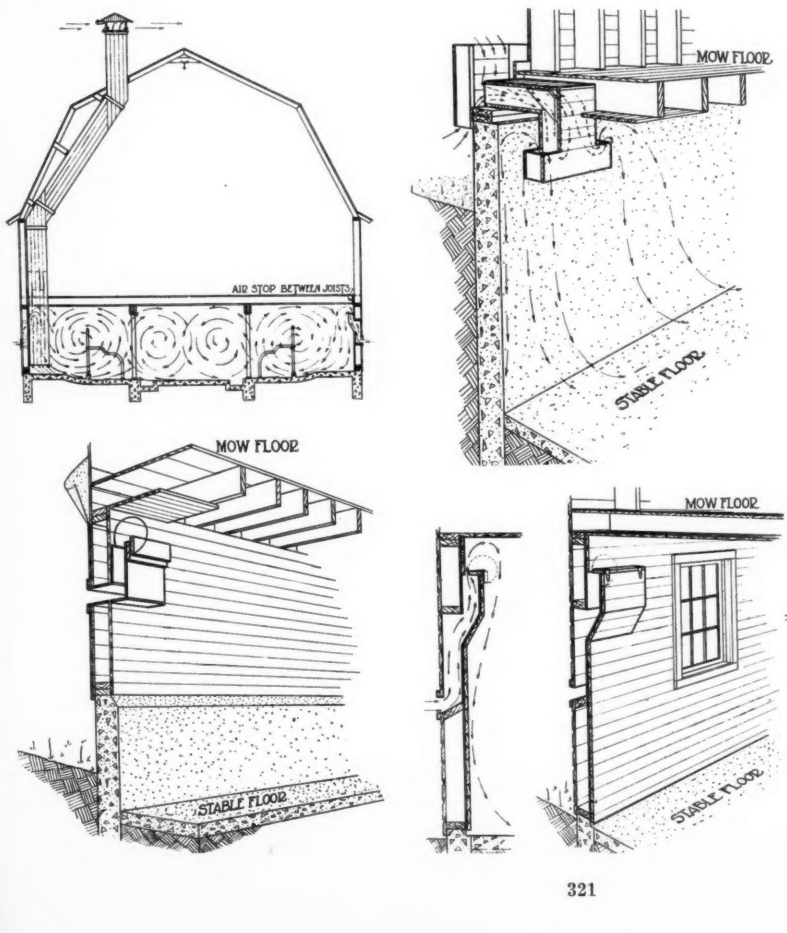
Now, how is the ventilation of such a stable accomplished? We must provide intakes to permit fresh air to enter the stable to supply the needs of the cows, and we must provide outtakes, either flues or electric fans, for the removal of odors, dust, excess moisture, etc.

We have assumed that the walls and ceiling are reasonably well built and insulated; that we have intakes and outtakes and cattle stanchioned in the stable. We have a means for the air to leave the stable and to enter the stable, and the idea which has prevailed for many years has been that this flow through the stable was all that was needed—simply a provision for air change as it was called.

Our work in New York state[3] indicates that this air change is not enough to give satisfactory stable conditions. We have been able through our studies of dairy stable ventilation to formulate a theory of ventilation and have built a system based on this new conception which has been called the Fairbanks-Goodman system. This system takes into consideration, beside the admission and exhaustion of the air, the internal movement or air movement within the stable.

M. A. R. Kelley, of the U.S.D.A. Bureau of Agricultural Engineering, has for years referred to the "dilution" of the stable air. I doubt if this has been fully understood, and I, for one, did not think much about it except in terms of air change. I took it for granted, but later I believe that probably it was this subconscious thought of dilution, together with our findings in actual dairy stables, that enabled us to formulate our theory and put into practice the ventilation of dairy

[3]Agricultural Engineering Department, N. Y. State College of Agriculture, Research Project I "Dairy Stable Ventilation."



(Upper left) This shows the action of the convection currents in the operation of the Fairbanks-Goodman system of ventilation. (Upper right) Location of ventilation intake for a masonry wall. (Lower left, lower right) Two styles of ventilation intake for a frame wall

stables situated in the first, second, and some parts of the third climatic zones.

The theory is briefly this:

1. The incoming air must be thoroughly mixed with the stable air to make a uniform mixture.
2. The incoming air must be controlled in such a way that it loses its velocity as it enters the stable.
3. The natural convection currents within the stable must be stimulated and assisted so that they will be always positive.
4. The system must be reasonably automatic with the minimum of equipment.
5. If No. 1 is accomplished, that is, if the fresh air is thoroughly mixed with the stable air, then the floor outtake flue may be placed at any point in the stable.
6. Also, if No. 1 is accomplished, one flue may be used where previously four to six outtake flues have been thought necessary.

As stated previously, the combination of forces are in action continuously so we must get our picture of the operation of the system as of a number of forces, factors, or functions in operation at the same time to visualize the stable with the cattle in it and with intakes and outtakes open and doors and windows closed.

First, the outtake flue may be either a tall insulated flue, or an electric fan used to exhaust the air from the stable at the floor level. This location is for the purpose of conserving heat to assist in the temperature control.

Second, heat is given off by the cows in each row. This heat warms the air about the cows causing it to rise toward the ceiling, and, of course, the air at the floor replaces this rising column of air.

Third, which way does the air move after it reaches the ceiling? It is obvious that with two rows of cows in the stable that, if the two rising columns moved toward the center after reaching the ceiling, they would meet and their velocity be retarded, but if each of these columns moves towards the walls of the stable, there will be nothing to slow them up but the cool walls and windows. What actually happens is that the air along the walls in contact with the walls is cooler than the other air in the stable and due to this difference in temperature is moving downward to the floor and over to the cows to supply the upward moving column about the cows. Therefore, the natural trend is along the ceiling from over the cows to the walls and down the walls.

HANDLING THE ENTERING AIR

Fourth, how about the entering air? It is much cooler than the air in the stable. We must warm, diffuse, and mix this air with the stable air as quickly as possible, or cold spots and drafts will result. The convection currents described above must not be retarded; they must be stimulated so that they can assist in the mixing and complete diffusion of the air. It is obvious, therefore, that this may be accomplished by bringing the fresh outdoor air into the stable near the ceiling at the side wall, and directing it straight upward so that it will strike the ceiling at right angles. This striking the ceiling head-on tends to stop the air and thus destroys its velocity. We then have (if we may visualize it momentarily) cold air at the wall and at the ceiling. What will this air do? It will fall naturally down along the cool wall, and as it moves downward, it is warmed and diffused into the convection current which is also moving down the wall.

If you will permit me to digress for a moment, we have found that this cold air falling along the wall may be so directed that it acts as an insulator between the stable air and walls and windows. We have been able to greatly reduce condensation on single glass windows by this means.

To continue, we thus have the convection current set up by the heat from the cows and the lack of heat of the walls, and we introduce the fresh cold outdoor air in such a way that it stimulates the convection current, and we accomplish the complete mixing and diffusion by these forces and the distribution of the intake flues uniformly along the walls.

Fifth, it is the location of the intakes that controls, to a great extent, the uniform distribution of the air in the stable, and not the outtakes as has formerly been assumed.

The foregoing is a brief visualization of what the ventilation of the dairy stable means. In all shelters in which we wish to maintain temperature, the general principles of the foregoing then apply. The essentials of such a system are

1. One or more outtakes for dairy stables up to 110 ft in length
2. The outtake for the cold climatic zones should exhaust the air from the floor level, and may be either a tall insulated flue or an electric fan
3. Intakes are necessary for any ventilation system, and these intakes should be placed along the wall, uniformly distributed to aid in the distribution and diffusion of the air.

ENVIRONMENTAL CONDITIONS MAINTAINED

The different kinds of farm animals evidently thrive under different environmental situations. Just what these environmental conditions should be for the different animals is the subject of several research projects now in force.

For the dairy stable we are rapidly approaching definite conclusions in regard to the environmental or air conditions most satisfactory to the dairyman. We have, therefore, been able to propose tentative standards for dairy stable ventilation which although not adopted are receiving consideration from those actively engaged in ventilation work on animal shelters. These dairy stable ventilation standards are:

1. **Temperatures.** The temperatures in the stable should be from 45 to 50 deg F with an allowable variation of ± 10 deg.

2. **Relative Humidity.** The relative humidity should be about 75 per cent and not over 85 per cent.

3. **Air Flow.** The air flow into and out of the stable should be from 50 to 60 cfm per cow and may vary from 40 to 80 cfm per cow in extreme cases.

4. **Internal Air Movement.** The internal air movement or convection currents should be positive at all times, that is, they should be constantly in operation in a certain direction to insure (a) a complete mixing of the stable air with the fresh air in order to produce uniform temperature and humidity and air movement conditions throughout the stable, (b) to act in the capacity of a partial insulation as they pass down the outside walls, and (c) to evap-

Table I. Electric Ventilation Systems for Dairy Stables

No. cows	No. of fans	Approximate capacity of fan, cfm	Approximate size of motor, hp	No. of intakes	Area of each intake, sq in
5 to 10	1	600	1/70	2	60
10 to 15	1	1000	1/50	4	60
15 to 20	1	1100	1/20	6	60
20 to 25	1	1500	1/10	8	60
25 to 30	1	1800	1/10	8	60
30 to 40	1	2400	1/6	12	60
40 to 50	2	1500	1/10	14	60
50 to 60	4	1000	1/50	16	60
60 to 70	4	1100	1/20	20	60
70 to 80	5	1000	1/50	20	60
80 to 100	6	1000	1/50	24 to 28	60

Note No. 1. For the colder climates, Zone 1 and 2, it is recommended that the fans be placed at the floor level and the intakes at the ceiling.

Note No. 2. For the milder climates, Zone 3 and 4, it is recommended that the fans be placed at the ceiling level and the intakes at the floor.

Note No. 3. There is some overlapping in Zone 3 which will modify the general recommendations above. However, it should be recalled that the floor outtake is recommended for use when the temperature is to be maintained as nearly constant as possible.

orate superexcess moisture which appears in windows and to some extent on walls and intakes during extensive cold periods.

THE NATURAL DRAFT SYSTEM

The Fairbanks-Goodman natural draft system of ventilation for dairy stables is described in Extension Bulletin No. 151[4] revised 1932, and I shall not go into details regarding it, except to say that the intake area is figured to be 100 per cent of the outtake area, if there is room for the intakes thus computed to be installed, but in most cases this is impossible, therefore, a minimum of 75 per cent is set for the intake area. (Each intake is 60 sq in in area.)

THE ELECTRIC SYSTEM

The proportioning of the electric system may be computed on the basis of air flow which is from 50 to 60 cfm per cow and in the factor of a maximum velocity through intakes of 300 fpm. I am including a table which will serve as a quick means of proportioning an electric system.

AGREEMENT AMONG STATES

At the present time all the state agricultural experiment stations do not agree in their recommendations of ventilation and ventilation systems for dairy stables. This need not alarm any of you for a close scrutiny of the recommendations show that, in general, the states are in agreement. It is only in some details, which may be influenced by particular climatic conditions, that they differ, and it is to the advantage of the problem that each state defend its own recommendations until such time as further data will clarify the particular detail.

The ventilation of animal shelters is not as simple as it may seem, as you may see from the partial list of shelters to be ventilated given at the beginning of this paper. I sincerely hope that the Committee on Farm Building Ventilation may be permitted to continue to function, and that it may have your hearty cooperation so that we may get together for you more complete information which will be of use to you in your agricultural engineering work.

[4]New York State College of Agriculture, Cornell University, Ithaca.

Handling Straw from the Combine

(Continued from page 320)

4. Cost of balers for small acreages
5. Extra power needed to operate and pull baler attached to rear of combine
6. Extra labor needed to operate baler pulled behind combine
7. Some danger of losing wire in fields to interfere with subsequent field operations.

The sixth principal method of saving straw from combines is with the use of extra large trailer type loose straw bunchers. When the straw can be collected in such large bunches, it may be reclaimed with sweep rakes and stackers, sweep rakes and power balers, loaded on racks by hand and unloaded with grapple forks or slings, or left in the field so that stock may feed from them during the winter months. Where such large trailer type bunchers are used the extension straw carrier will be an added advantage.

Particularly in North Dakota and Canada do we hear favorable comment concerning barged grain. From information now available it would seem that, if the grain is properly loaded in these barges, it is possible to make good sized stacks, which will not only cure properly, but shed water. This system of harvesting will leave the straw in piles. A report from Michigan showed the satisfactory use of a homemade trailer type barge the past two years. It is possible that this barge can be so constructed that it can be used to cut and stack grain, which gives a certain concentration of the straw when the stacks are threshed, or the barge might be pulled behind a combine to concentrate the straw when combining direct or from windrows. The windrowing unit might not only be used to windrow grain, but also be a part of the barge unit if it is desirable to barge or stack the grain for curing. The extension straw carrier might be adapted to be a part of the windrowing barge unit, or be attached to the combine when threshing from the barge stacks or using the combine much as a stationary thresher. Some advantages to be secured by the use of a barge are:

1. Straw can be dumped in large piles
2. Large piles can be dumped in windrows in the field
3. The barge is available for barging grain for curing
4. Straw left in big piles by the barge is easy to bale, feed, or move.

The use of the barge will increase the cost of equipment to some extent and will ordinarily require one extra man to load the straw.

The seventh method of handling straw from combines is with the use of self-baler attachments. Attachments of this type used in Europe are known as "straw trussers." Some of the advantages of the combine self-baler attachment are:

1. It is not heavy
2. Little power is required to operate it
3. It does not require much attention of the combine operator
4. Bundled straw is easy to handle with fork
5. Bundled straw can be stored in smaller space than loose straw
6. Bundled straw is easier to sell than loose straw
7. Chaff and light grain can be saved
8. No wires used to be lost in fields.

The following facts concerning the use of the combine self-baler attachment should be kept in mind:

1. Extra cost of attachment
2. Cost of twine
3. Time and labor to get bundled straw out of field
4. Bundled straw should not be permitted to get water soaked
5. Short, brittle straw will not bundle as well as long straw.

At this time it is not possible to furnish accurate cost data concerning each of these methods of saving straw. However, it is hoped that those particularly interested in saving straw from combines will find it possible to now adapt one of these methods to their own conditions. The kinds of straw, acreages, value of straw, cost of equipment, labor, etc., is so variable that it would be somewhat difficult to present cost data applicable for all parts of the country.

In closing I wish to list the seven general methods of saving straw from combines:

1. Reclaiming straw which has been left in windrows
2. Reclaiming straw which has been bunched with standard combine bunchers
3. Cutting the straw high with the combine so that the stubble may be mowed and handled about the same as hay
4. Threshing barged, stacked, or bundled grain in feed lots or field
5. Using extension carriers on combines to load the straw on racks, feed directly into balers, or concentrate windrows
6. Use extra large trailer type loose-straw bunchers
7. Bale or bundle the straw with combine baler attachments.

The Physical Properties of Soil of Interest to Agricultural Engineers[1]

By L. D. Baver[2]

IF ONE REVIEWS the development of soil science during the last one hundred years, it will be readily seen that investigations concerning plant nutrition and soil chemistry have stood and now stand considerably in the foreground. Investigations of the physical properties of the soil have remained very much in the background. Considerable attention, however, is being devoted at the present time to a study of those physical factors which affect, either directly or indirectly, the growth of plants on any particular soil. It is now distinctly evident that a knowledge of the physical properties of the soil is not only helpful but also essential in a thorough understanding of many of our soil management problems. The importance of this knowledge is manifested in two ways: (1) in the development of a fundamental, scientific basis for tillage operations, and (2) in the study of the environmental conditions under which plant growth and other biological activities take place.

It is readily seen, therefore, that studies of the physical properties of the soil are of interest not only to soil investigators, but also to those agricultural engineers who are concerned with problems involving the soil. It is the purpose of this paper to briefly discuss those physical factors which should be of vital interest to agricultural engineers. It is hoped that such a discussion might be suggestive of certain cooperative projects which can be carried out towards the solution of many unsolved soil management problems.

A DESCRIPTION OF SEVERAL PHYSICAL PROPERTIES OF SOILS

There are many factors which could be mentioned in a discussion of the physical properties of the soil. In this paper, however, we will deal only with those properties which play the most significant roles in the problems that confront the agricultural engineer. These properties are texture, structure, and consistency. Before discussing the significance of these factors and the mechanisms of their effects, it will be necessary to describe each of these terms.

Texture. Texture refers to the size of the individual primary particles which constitute the soil mass. These particles are usually classified into sand, silt, and clay fractions. The lower limit of size of the sand fraction is 0.05 mm. in diameter; silt ranges from 0.05 to 0.005 mm.; clay is considered as being smaller than 0.005 mm. in diameter. Clay is often subdivided into a much smaller fraction called ultra-clay or colloidal clay. Although the exact upper limit of the clay colloids has not been definitely established, it is usually considered as being below 0.001 mm. There is some evidence which indicates that all clay is colloidal. It is fully recognized, however, that clay is the active fraction of the mechanical constituents of the soil because of the large amount of surface per unit weight of material. The soil can be pictured, therefore, as being made up of a skeleton (sand and silt), and of an active material which is responsible for most of its physical and chemical properties.

Structure. The structure of a soil is defined as the arrangement of its particles. Soil particles refer not only to the individual mechanical elements, such as sand, silt, and clay, but also to the crumbs and granules that have formed by the aggregation of smaller mechanical fractions. Thus there are primary and secondary particles in the structural make-up of the soil. It is of utmost importance to distinguish between the structure of the soil (the arrangement of its particles) and soil structure relationships which are dependent upon particle arrangement. Permeability measurements, for example, are commonly used to determine "soil structure." As a matter of fact, they do not determine whether a soil has a granular or columnar structure; they only serve as an index to structure in that they tell whether or not the soil particles are arranged tightly or loosely.

There are two indices to structure which are unusually helpful in soil structure studies. These are the state of aggregation and the porosity of soils. The state of aggregation is the extent to which the smaller mechanical fractions in a given soil are aggregated into crumbs or granules. It is determined by making a mechanical analysis of the soil, with and without dispersion. Such a determination is shown in Fig. 1. A complete description of the technique employed is given in another paper[3].

The porosity of a soil is divided into two kinds of pore space: (1) capillary porosity, i.e., small pores which are responsible for the water capacity of the soil and (2) non-capillary porosity, i.e., large pores which do not hold water by capillarity and which are responsible for the air capacity of soil. Porosity measurements are easily made according to a modified method of Sekera[4], the exact details of which will appear in a later publication. Capillary and non-capillary porosity provide a valuable means for estimating the aeration and water absorption and movement in soils. Their relationship to each other for a given soil is graphically illustrated in Fig. 6.

Consistency. Soil consistency is defined as a term expressing the manifestation of certain physical forces of cohesion and adhesion acting within the soil at various moisture contents. The main forms of consistency and the physical forces responsible for their manifestation may be summarized somewhat as follows:

Moisture content of the soil	Low	Optimum	Moderately high	High
Consistency form	Harsh Hardness	Soft Friability	Plastic Plasticity	Viscous Viscosity
Forces involved	Forces of cohesion between soil particles	Forces of cohesion and adhesion as modified by the presence of an incomplete water film	Surface tension forces of water films between particles	Forces of cohesion between water molecules

The relationship of consistency to the moisture content and the corresponding effects of the water films between the soil particles is shown in Fig. 2. These consistency forms have a very important bearing on problems involved in tillage, which will be discussed later in this paper.

After this brief description of several important physical properties of the soil, the relation of these physical factors to tillage and drainage will now be discussed.

[1]Paper presented at a session of the Power and Machinery Division of the American Society of Agricultural Engineers during the 26th annual meeting of the Society at Ohio State University, Columbus, June 1932. A contribution from the Department of Soils, Missouri Agricultural Experiment Station—Journal Series No. 347.

[2]Assistant professor of soils, University of Missouri.

[3]Baver, L. D., and Rhoades, H. F. Aggregate analysis as an aid in the study of soil structure relationships. To be published in Journ. Amer. Soc. Agronomy, 1932.

[4]Sekera, F. The usable water-capacity and water movement in soils. Zeit. Pflanz. Dung u Boden 22A:87-111, 1931.

THE PHYSICAL PROPERTIES OF THE SOIL INVOLVED IN TILLAGE

The purpose of tillage is to put the soil into the best possible condition for the growth of plants. There are three factors which affect the attainment of this objective, namely, (1) mechanical manipulation to permit the turning under of surface material and the production of a good seedbed, (2) the regulation of soil moisture between extreme drought and wetness, and (3) the control of weeds.

History of Tillage Practices. Most of the research on soil tillage has been associated with studies of mechanical manipulation in its relation to the production of a good seedbed. It is interesting to note the development of agricultural implements and tillage as our knowledge of the physical properties of the soil progressed.

Physics of Plow Action. Following the design of the moldboard, the theory of the physics of plow action was developed. It was assumed that the lower soil in passing over a curved plow surface travels farther than the surface soil. The soil is thereby divided into different layers which travel at different speeds causing a pulverizing action. Recent experiments of Nichols[5], however, have shown that the action of the plow is just the opposite from this theoretical action, in that pulverization takes place at right angles to the curve of the moldboard and not parallel to it.

On the basis of his studies of the nature of plow action, Nichols has classified the variables entering into the dynamic properties of the soil involved in tillage and implement design as follows:

1. Shear value: The slipping of soil over soil, or the internal resistance of a soil to any movement of its particles.
2. Friction: Sliding friction between metal and soil, in which, according to the moisture content, there are phases of friction, adhesion, and lubrication.
3. Resistance to compression: The reaction of the soil to pressure.
4. Cohesion: The sticking together of soil particles as a result of the film tension of moisture films between the finer particles.
5. Adhesion: The sticking of soil to metal as a result of moisture films between soil particles and the metal.

He assumed that these dynamic properties depend upon the following soil factors: (1) particle size, (2) colloidal content, (3) moisture content, (4) organic matter, (5) apparent specific gravity (a measure of structure), and (6) chemical composition of the colloid.

Soil Consistency and Tillage. Since soil consistency is a term used to designate the manifestation of the physical forces of cohesion and adhesion acting within the soil, and, since soil dynamics is a study of these same forces, a distinct correlation between the two should be expected. Such a correlation was obtained by Nichols and the writer which has been discussed in some detail in other publications [6, 7, 8]. A brief summary of these results is shown in Fig. 3. It is readily apparent that in plastic soils, consistency plays an important role in tillage operations.

The forces involved in cohesion and shear are at a maximum at the lower limit of plasticity. It is at this point that the film tension is at a maximum. Adhesion increases to a maximum within the plastic range as the number of films between the soil particles and the metal increases to a maximum. Adhesion, cohesion, and shear decrease as the thickness of the moisture films increases. This is due to the fact that film tension decreases with the thickness of the film.

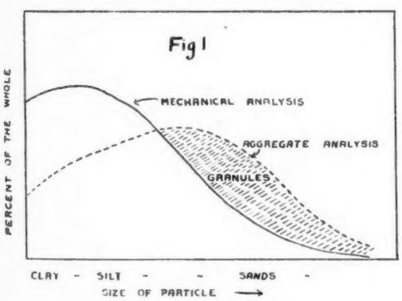
Compression of the soil is the greatest within the moisture range of plastic consistency due to an orientation of

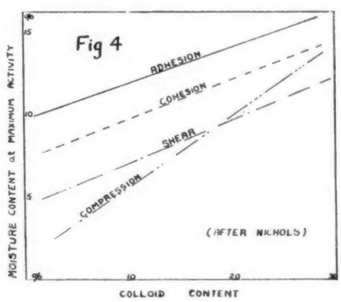
[5]Nichols, M. L. Methods of research in soil dynamics as applied to implement design. Ala. Exp. Station Bul. 229, 1929.

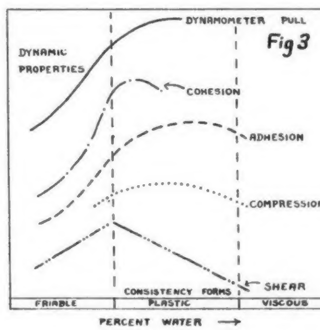
[6]Nichols, M. L. and Baver, L. D. An interpretation of the physical properties of soil affecting tillage and implement design by means of the Atterberg consistency constants. Proc. 2nd Int. Soil Congress, Leningrad, 1930.

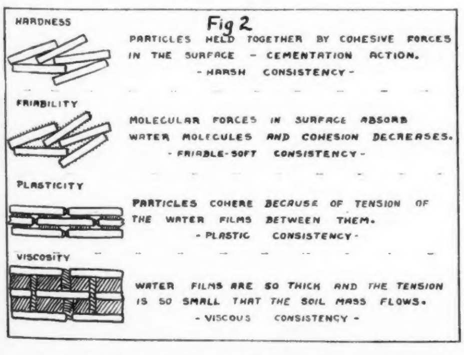
[7]Baver, L. D. The Atterberg consistency constants: Factors affecting their values and a new concept of their significance. Journ. Amer. Soc. of Agronomy 22: 935-948, 1930.

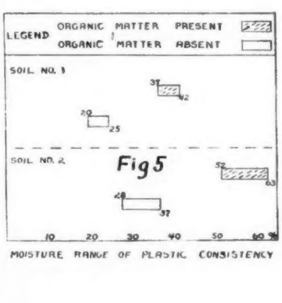
[8]Nichols, M. L. The dynamic properties of soil: I. An explanation of the dynamic properties of soils by means of colloidal films. AGRICULTURAL ENGINEERING, Vol. 12, 1931.











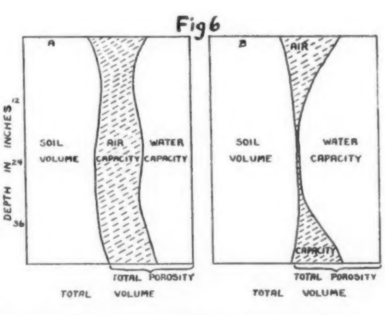


Fig. 1. The degree of aggregation of soils. Fig. 2. Soil consistency as related to the moisture content. Fig. 3. The dynamic properties of soils and soil consistency (plastic soils). Fig. 4. The dynamic properties of nonplastic soils as related to the colloid content. Fig. 5. The effect of organic matter on soil consistency. Fig. 6. The porosity of soils

particles as pressure is applied. The dynamometer pull, which is a measure of the sum total of all of the other forces, increases with the moisture content to a maximum within the plastic range. These results show rather vividly that the most efficient tillage is performed when the moisture content of the soil is such as to give it a soft, friable consistency. It has been shown, from a study of a large number of soils, that the maximum cohesion, adhesion, shear, and dynamometer pull increase proportionally with the plasticity of the soil. Keen[9] has shown that the soil's resistance to the passage of implements is proportional to its plasticity. Plasticity is dependent upon the clay content.

In non-plastic soils Nichols[8] has shown that adhesion, cohesion, shear, and compression are dependent upon the percentage of colloidal material present. This is illustrated in Fig. 4. It is apparent that in all of these studies the clay and colloidal fractions of the soil are responsible for the manifestation of the forces involved in these dynamic properties.

Physical Properties of Soil and Implement Design. In all of these determinations Nichols determined the apparent specific gravity of the soil mass. In this way he has accounted for differences in structure relationships, as well as consistency variations. As a result of these fundamental studies, he has arrived at a basis for the design of moldboards, based on the physical properties of the soil. In other words, he has interpreted the fundamentals of tillage and implement design from careful analysis of the texture, structure, and consistency of the soil as they affect the dynamic forces involved in cultivation. This is an important milestone in agricultural engineering and soil research.

Moisture Content of Soils and Manipulation. Since the primary object of tillage is to manipulate the soil in such a way as to make it a suitable environment for plant growth, it is obvious that the moisture content of the soil will determine the effectiveness of the manipulation. The results previously discussed showed that the most efficient tillage should be expected when the moisture content of the soil corresponds to that of a soft, friable consistency. Mechanical manipulation above this moisture content results in a puddling action, since the soil is plastic and is easily molded into any shape or form. Cultivation below the range of friability causes the formation of clods, since the soil is more or less cemented together by the forces of cohesion between the solid particles.

The moisture content of the lower limit of plasticity, or the upper limit of friability, is easily determined. It is characterized as that moisture content at which the soil can just barely be rolled out into a wire[7]. If the amount of moisture is below this limit, the soil is crumbly and friable. The limit varies with different soils and is influenced by the clay content, the chemical nature of the clay, and the amount of organic matter present. The significance of this limit in soil tillage is shown in Fig. 5, which shows the variations in the moisture content of the plastic range as affected by the presence of organic matter. Soil No. 1 can be cultivated at a moisture content of 37 per cent in the presence of organic matter; in the absence of organic matter it becomes too wet at 20 per cent moisture. The presence of organic matter in soil No. 2 permits cultivation at 52 per cent moisture; in the absence of organic matter the moisture content of plowing is lowered to 28 per cent. The variations are associated with the high absorptive capacity of the organic matter for water as well as its granulating effects upon the clay particles. These data point out rather strongly the importance of organic matter in tillage operations. The moisture content of the lower limit of friability can only be approximately determined. It may be estimated by squeezing the loose soil together in the palm of the hand. If the soil clings together the moisture content is in the proximity of the soft, friable consistency.

[9]Keen, B. A. The physical properties of the soil. Longmans, Green and Co. London, 1931.

Changing Structure by Manipulation. Mechanical manipulation changes the structural condition of the surface layer of soil to a considerable extent. Most manipulative operations are designed to promote g nulation; that is, to change large clods to smaller granules and to break up an apparently crumbless soil mass into one that is granulated. Slipher[10] has discussed this subject somewhat in detail at a previous meeting of your group. It must be kept in mind, however, that any granulation which is caused by tillage is more or less temporary. The granules are rather easily broken down in an excess of water. The amount of this breaking down into finer particles after a rain determines to a considerable extent the frequency of cultivation. Whenever a soil has become so compact that it loses its friability, manipulation at the correct moisture content will restore granulation. The amount of manipulation necessary to maintain a state of granulation varies with different soils as affected by the presence of organic matter and lime. These agents are inducive to the formation of relatively stable granules or aggregates which are fairly resistant to the disintegrating action of water. Experiments at the University of Missouri have shown that cultivation of the Putnam silt loam has resulted in a breaking down of 30 per cent of the original aggregates. This is primarily due to a loss of organic matter and lime and not to manipulation. It is possible, however, to manipulate a soil too much and thereby destroy its granulation to a considerable extent.

Tillage and Moisture Conservation. There is considerable disagreement in the literature concerning the beneficial effects of cultivation in the conservation of soil moisture. Call and Sewell[11] in Kansas, Veihmeyer[12] in California, and Rotmistroff[9] at Odessa, Russia, found that no significant conservation of moisture could be obtained by dust mulching. On the other hand, numerous investigators have concluded that considerable losses of water took place at the surface of the soil due to upward capillary movement; this loss could be prevented by the maintenance of a dust mulch. There are several important factors that must be considered before passing judgment on the merits of these two opposite opinions. In the first place, it is known that the capillary movement of water takes place over short distances only. Therefore, unless a permanent or temporary water table exists within about five or six feet from the surface, the loss of water at the surface as a result of capillary action will be insignificant[9]. In the second place, it is also known that water evaporates within the soil and escapes in the vapor phase through the soil pores. Evaporation within the soil occurs at a very slow rate at depths of several inches below the surface, except when the soil is extremely porous. If the soil at these depths is kept relatively cool as compared with the surface, evaporation will be kept at a minimum. This can be accomplished to some extent by the presence of shade and mulches.

The main objectives, therefore, in the control of the loss of water vapor is in the conservation of the small rains that are largely retained in the top several inches and the prevention of water losses by transpiration through weeds. Undoubtedly a granular surface will promote the absorption of water and indirectly tend to reduce evaporation to some extent.

Packing the Soil and Moisture Movement. Many agricultural implements have been designed to break up large lumps or clods and to pack the soil so that a relatively smooth surface is obtained. These implements are also used on crops during the early stages of growth. The effect of this packing is to squeeze the moist soil in closer contact with plant roots making more water available to them by increasing the amount of available water per unit volume of soil. It is generally assumed, however, that

[10]Slipher, John A. Mechanical manipulation of soil as it affects structure. AGRICULTURAL ENGINEERING 13 : 7-10, 193?.

[11]Call, L. E. and Sewell, M. C. The soil mulch. Jour. Amer. Soc. Agronomy 9: 49-61, 1917.

[12]Veihmeyer, F. J. Some factors affecting the irrigation requirements of deciduous orchards. Hilgardia 2: 125-284, 1927.

the consolidation causes water to ascend as a result of capillary action. Since this operation is done at very low moisture contents of the soil, it is readily seen that capillary movement would be too slow and insignificant to be of much benefit to the plant. If there was sufficient water in the soil to cause capillary movement upward, consolidation would result in water losses at the surface.

PHYSICAL PROPERTIES OF SOILS INVOLVED IN DRAINAGE

Drainage is one of the most important soil problems in certain sections of this country. There are two distinct types of drainage problems, namely, the removal of excess water from swamps and the lowlands adjacent to streams and the drainage of level upland soils. The former problem is usually approached by a rapid removal of surface water by means of a system of drainage ditches. Drainage of level uplands is ordinarily attempted by the use of tile drains. The efficiency of the drainage operation in either case is determined by the completeness of the surface removal of water and by the amount of subsurface drainage. In order to provide sufficient aeration for the growth of crops, there must be a removal of this subsurface water. The effectiveness of subsurface drainage is wholly dependent upon the structural condition of the soil profile.

Soil Structure and Subsurface Drainage. The extent to which the removal of water takes place in a soil is closely related to the degree of aggregation (granulation) and amount of non-capillary pores. This relationship is clearly illustrated in Fig 6. When a soil comes in contact with water, it will absorb water in the small pores by the forces of capillary action. The larger pores which can not hold water capillarily will remain filled with air. If an excess of water is present, however, the air will be expelled from these pores and they will become saturated with water. On the other hand, if the different layers in the entire soil profile contain sufficient non-capillary pores, this excess water will drain away through these large pore spaces. Such a soil profile is shown in Fig 6 (A). The non-capillary pores may be pictured as being the channel through which water percolates through the soil. It is obvious that percolation of water through the small capillary pores would be an extremely slow process. If a heavy clay layer was present in the subsoil of the profile, subsurface drainage would be greatly hindered. This is shown in Fig 6 (B). The heavy clay layer at a depth of twelve inches is very impervious to water because of the low non-capillary porosity. Since it has a high capillary porosity it will retain a large amount of water. The surface soil will become saturated during wet weather and remain in this condition until the excess water in the soil pores has evaporated. Percolation downward will be negligible, even though the soil is fairly permeable at a depth of thirty inches. This illustration clearly shows that the permeability of a soil is determined by the rate of percolation through its last permeable horizon.

The condition pictured in Fig 6 (B) obtains for many of the level upland soils of the Middle West, especially in Missouri, southern Illinois, Indiana, and Ohio. Drainage of these soils is extremely difficult. The heavy layer is too close to the surface to permit placing tile drains on the top of the impervious horizon. Tiles will not function if they are placed in or beneath this layer. Successful drainage of these types of soil has not as yet been accomplished. There are several factors which enhance the chances of obtaining a crop during wet seasons, namely, (1) a rapid removal of surface water and (2) the use of a cropping system including a legume, such as sweet clover, which can be plowed under and thereby increase the porosity of the surface layers. It is also possible that these deep-rooted legumes may penetrate this impermeable layer and cause an increase in its permeability.

The drainage of heavy bottom land soils by means of drainage ditches presents a similar problem to some extent. After the main ditches for removing most of the surface water have been laid out, it is necessary to provide for numerous laterals. These laterals are supposed to serve the purpose of allowing any remaining surface water to reach the main ditches and of removing the excess water from the subsurface. The efficiency of these laterals is very closely related to the nature of the soil.

Soil Porosity and Aggregation. The question of determining the correct spacing of tile drains and drainage ditches in various soils immediately suggests itself. At the present time there is little experimental data which might be used to answer the question. This is especially true in this country. Some Europeans, however, are using determinations of the degree of aggregation of soils as an index in drainage practices. They have correlated in a few cases the depth and spacing of tile drains with the texture and structure of the soil.

It has been found at the University of Missouri that the non-capillary porosity of soils is closely related to the degree of aggregation or granulation of the soil. Determinations of the degree of aggregation by means of the method previously mentioned should provide a valuable means for studying this problem. A splendid opportunity is hereby presented for a cooperative project between agricultural engineers and soils investigators in order to solve this important soil management problem.

CONCLUSIONS

A knowledge of the physical properties of the soil such as texture, structure, and consistency and related factors is highly essential for a successful study of most of the soil problems which confront the agricultural engineer.

The development of cultivation and tillage implements has progressed as our knowledge of the physical properties of soils has developed.

As a result of a careful study of the effect of texture, structure, and consistency upon the dynamic properties of soil involved in tillage, a scientific foundation for implement design has been developed, based on the physical properties of soils.

The moisture content at which tillage is most efficient is dependent upon the consistency of the soil. It is characterized by the moisture content of the soft, friable consistency. Mechanical manipulation causes only a temporary formation of a certain structural condition. Frequency of manipulation is determined by the need for the restoration of this condition of structure.

The conservation of moisture by cultivation is associated with the control of weeds, with the maintenance of such structural qualities of the soil which enhance water absorption and, to some extent, with the hindering of evaporation because of the formation of a dust mulch.

Drainage problems are closely related to the structural relationships in soils. The efficiency of soil drainage is determined by the completeness of the surface removal of water and by the amount of subsurface drainage. The effectiveness of subsurface drainage is wholly dependent upon the degree of aggregation and the non-capillary porosity of the soil profile.

The permeability of a soil is determined by the rate of percolation through its least permeable horizon or layer.

The depth of the heavy subsoil layer determines the effectiveness of tile drainage in most upland soils. The porosity of the soil also determines the effectiveness of supplementary lateral ditches in the drainage of lowland soils.

It is apparent from this discussion that more cooperative research between agricultural engineers and soils men is necessary for the solution of many of the existing soil problems. This is especially true with such problems as the correct spacing of tile drains and lateral ditches, moisture regulation and tillage, and so forth. The agricultural engineer should endeavor to interpret more of his results in light of the properties of the soil with which he is working. The soils investigator should endeavor to study to a greater extent the soils problems which confront the engineer.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

The Volatility of Motor Fuels, G G Brown (Michigan University [Ann Arbor], Engineering Research Bulletin 14 [1930], pp [VIII] + 299, figs 110).—Detailed studies regarding the effect of fuel volatility on the performance of internal-combustion engines are reported. The details of the technic involved in the studies are described. The studies themselves dealt with equilibrium volatility of motor and aviation fuels; ease of starting; effective volatility under operating conditions; the relation between atmospheric temperature, volatility, and acceleration performance; and vapor pressure and vapor lock.

The results in general indicate that the ease with which an internal-combustion engine will start, the length of time required to warm it up, and the character of its performance are almost wholly dependent upon the volatility of the fuel, as indicated by the distillation curve of the American Society for Testing Materials. The 10 per cent point is related in the lowest engine temperature at which satisfactory starting may be obtained and the lowest mixture temperature at which the engine may be operated. The 35 per cent point is related to the lowest mixture temperature at which satisfactory performance may be obtained during the warming-up period and therefore determines the length of time necessary to warm up the engine. The 65 per cent point is related to the lowest mixture temperature at which perfect performance can be obtained. For these reasons the 10, 35, and 65 per cent points should be low to insure satisfactory starting, warming up, and general performance. The 90 per cent point, however should not be so low as to indicate a dry mixture, for this means loss in power or acceleration. The vapor pressure of the fuel, or the 10 per cent point, should not be so low as to indicate trouble from vapor lock.

It was found in the study of the relation between atmospheric temperature, volatility, and acceleration performance that that part of the distillation curve from 65 to 100 per cent is of little or no practical importance in determining effective volatility in modern engines, provided the 90 per cent point is not so high as to prevent efficient combustion of the fuel nor so low as to supply a practically dry mixture. The first 35 or 40 per cent of the distillation curve is the controlling factor in determining fairly satisfactory performance during the warming-up period, providing the conditions stated concerning the 90 per cent point are fulfilled.

Appendixes are included which present data on the relation between volatility and knock rating and the determination of the American Society for Testing Materials distillation curve of blends from the distillation data of the two blending materials.

Binding Twine Investigations [trans title], H R Schacht (Den Kongelige Veterinaer og Landbohjskole [Copenhagen, Denmark], Aarsskrift [1928], pp 56-75, figs 7; Ger abs, pp 73-75).—Tests of Danish binding twine for use in binding grain and baling straw are reported, special attention being given to length of strands, resistance to wear stretching ability, and regularity of twist as compared to foreign twines.

No difference was observed in the utility of cross and cylindrically wound spools of twine, although it is noted that the cylindrically wound twine gave better mechanical test results. The test data are subjected to analysis but no conclusions are drawn.

Recent Research on the Influence of Forests in Checking Erosion and Surface Run-Off, S Cabianco ([International Review of Agriculture], Monthly Bulletin of Agricultural Science and Practice [Rome], 23 [1932], No 1, pp 25-35).—A summary of investigations by others bearing on the subject is presented under the headings of evolution of land reliefs, retention of water by the soil, evaporation, control of run-off and stream flow, and erosion. A list of 20 references is included.

Economics of Highway Bridge Types, C. B. McCullough (Chicago: Gillette Publishing Company, 1929 pp X + 246, figs 193). —This volume presents a concise discussion of the fundamentals of economic analysis and type selection for ordinary highway bridge structures. It contains chapters on general factors controlling type selection, fundamentals of economic analysis, bridge types, renewal and maintenance costs, unit costs, and illustrative problems in type selection.

A New Procedure for the Destruction of Weeds [trans title], G Carre (Journal of Agricultural Practice, 96 [1932], No 7, pp 134-136, figs 3).—In a contribution from the French Academy of Agriculture, a new mechanical method for the destruction of weeds in growing grain by the spraying thereof of a solution of a dilute sulfuric acid is described and illustrated. The machine consists essentially of a shoe passing between the rows of growing grain at a height of from 15 to 30 cm which covers a nozzle which in turn supplies the acid on the roots of weeds between the grain rows.

The best results were obtained when the spray was applied at a height of 15 cm. In spring grain a 20 per cent solution of sulfuric acid gave the best results, and a 30 per cent solution gave the best results in fall grain, in both instances the application being from 400 to 500 1 = liters per hectare. When the shoe was regulated to the height of 15 cm a minimum injury to the growing grain resulted.

Streamflow from Rainfall by Unit-Graph Method, L K Sherman (Engineering News-Record [New York], 108 [1932], No 14, pp 501-505, figs 7).—A method is described whereby the observed run-off following an isolated one-day rainfall forms the basis for computing the run-off history for the same watershed corresponding to a rainfall of any duration or degree of intensity. From the known hydrograph the unit graph must be determined, representing 1 in of run-off from a 24-hour rainfall. The daily ordinates of the unit graph can then be combined in accordance with the variation in daily precipitation figures so as to show the run-off from a storm of any length.

Charcoal-Gas Fuel for Tractors, A H E McDonald (Agricultural Gazette of New South Wales [Sydney] 43 [1932] No 2, pp 135, 136, fig 1).—The use of charcoal gas in tractors is briefly described and the results of a power test reported. In a comparison of kerosene with charcoal gas in general-purpose tractors drawing four-furrow disk plows in clay loam soil, the charcoal-gas fuel accomplished about the same result as kerosene at a considerably lower cost.

Electric Ploughing (Rural Electrification and Electro-Farming [London] 7 [1932], No 82, pp 300-302, fig 1).—A brief review is presented of the progress made in electric plowing in Europe, and the conclusion is drawn that the status of this practice justifies further consideration of its adaptation to farm work.

Utilization of Electrical Energy in Agriculture, H Champigny (Utilisation de l'Energie Electrique en Agriculture. Paris: Chemin de Fer de Paris a Orleans, 1929, 3 ed, pp 88, figs 35).—This is an illustrated bulletin describing the practical phases and features of rural electrification in France. It deals especially with the construction and maintenance of power lines, small belt power and other uses of electricity, including field plowing, and with financing and desirable legislation.

Standards and Specifications for Nonmetallic Minerals and Their Products, J Q Cannon, Jr (U S Department of Commerce, Bureau of Standards Miscellaneous Publications 110 [1930] pp IX + 680, figs 243).—Standards and specifications are included for such minerals of agricultural engineering interest as fuel and illuminating oils, including gasoline and kerosene; lubricating, cylinder, and machine oils; lubricating greases; and cement and concrete.

The Practical Electrical Illumination of Plants and the Cost [trans title], S Oden, G Kohler, and G Nilsson (Meddelande fran Centralanstalten for Forsoksvasendet pa Jordbruksomradet [Stockholm, Sweden], No 393 [1931], pp 53, figs 23; Ger abs, pp 49-52).—The results of experiments on the technical adaptation of artificial electrical illumination for plant culture during the three winter months are reported. Particular attention was devoted to determining the most useful and economical sources and arrangement of light for greenhouses and hotbeds.

Three different types of greenhouse were experimented with, including small, low but relatively broad houses with middle aisle and low side beds; large, relatively broad houses with high beds in the middle, as well as along the side, and aisles along both sides of the middle beds; and large houses with relatively low side walls and center and side beds.

Lighting periods of 500, 1,000, 1,500, and 2,000 h per year and three different light intensities in two different lengths of house were studied. The cost of illumination from arc lamps was less than from gas-filled incandescent lamps as regards current consumption, but the cost of installation and maintenance was about 25 per cent higher. The higher the current rate the more favorable were the cost results with arc lights. The arc lamps also presented the difficulty of nonuniform illumination, which was not nearly so marked with the gas-filled incandescent lamps.

The best yield results were obtained with spinach in the first type of greenhouse illuminated with a row of show-window lights set under the roof ridge on one side of the beds. The lamps were spaced one-fourth of the distance between the lamps and the beds. Good yield increases were obtained from the other types of greenhouse over houses not illuminated. In the second type a row of tin reflectors was placed under the roof ridge, these being supplemented by similar reflectors in the corners between the roof and side wall. The lamps were spaced 0.4 and 0.5 the distance between the surface of the bed and the lamps. In the third type of house a row of lights was set under the roof ridge in opal glass cylinders, and flat enamel reflectors were used. The lamps were spaced 1 to 1.5 the distance between the beds and the lamps and the width of the house was limited to 2.8 times this distance.

Wind Power and Power Lines in Agriculture, A Decker (Windkraft und Uberlandkraft in der Landwirtschaft. Dissertation, Hessische Ludwigs-University, Giessen, 1930, pp [7] + 108 + [5], pls 3).—A study is reported of the comparative efficiencies and economies of wind and of central-station power in Germany.

It was found that in general wind power can not compete with central-station power from the standpoint of unit cost of the energy alone, owing to the high cost of the equipment for the isolated plant and the maintenance thereof. The uncertainty of adequate and constant wind is also against heavy investments in equipment for the harnessing of wind power. The studies showed, for example, that regions having an average wind velocity of less than 4 m (13.12 ft) per second can not make constant economical use of wind power except in rare cases where the cost of overhead transmission systems from a central station is prohibitive.

Data on wind conditions in Germany are presented showing that the regions most favorable for the economical use of wind power are the north and east coasts.

Atmospheric Corrosion of Metals, J C Hudson (Faraday Society [London] Transactions, 25 [1929], No 5, pp 177-252, figs 20).—This report deals essentially with the results of field tests on the atmospheric corrosion of 16 different nonferrous metals and alloys including copper, arsenical copper, cadmium-copper, tin bronze, aluminum bronze, brass, nickel, pure and commercial zinc, a nickel-chromium alloy, copper-nickel alloys, and lead. The metals were exposed in the form of plates and of wire at five experimental stations representative of various types of atmosphere. The corrosive was measured by three independent methods, which were based on (1) determinations of the increase in weight of specimens exposed in Stevenson screens, (2) of the increase in the electrical resistance of fully-exposed specimens, and (3) of the loss in weight of fully-exposed plate specimens.

In the weight increment tests of the 12 materials exposed, copper, cadmium-copper, arsenical copper, tin bronze and aluminum bronze gave the smallest weight increments. The results indicated that there is a critical humidity for each metal, determined by the vapor pressure of its corrosion product, above which condensation will occur on its surface. This critical humidity varies for different metals and appears to approach saturation in the case of aluminum, copper, and possibly also iron.

In the electrical resistance tests, the resistance changes observed over a period of exposure of one year ranged from 0.65 per cent for nickel-chromium to 6.01 per cent for so-called "compo" wire. The nickel-chromium and tin bronze suffered the smallest increase in electrical resistance. In the weight-loss tests, nickel-chromium was the least corroded material after exposure for a year.

The chief conclusion from the results in general is that the materials tested are not appreciably corroded when exposed to the atmosphere under normal conditions. The provisional conclusion is drawn that in the majority of cases of these metals corrosion will be, at most, directly proportional to time. In general, the rate of corrosion was much greater for fully-exposed specimens than for specimens exposed in a Stevenson screen. The results of the resistance tests gave higher values for the corrosion of these metals than the corresponding loss-in-weight tests.

Fuel Briquettes from Southern Pine Sawdust, C A Basore (Alabama Polytechnic Institute [Auburn], Engineering Experiment Station Bulletin 1 [1930], pp 28, figs 7).—The results of studies of a process for the manufacture of sawdust briquets from waste wood are presented and the resulting process described. The process produces a high-grade fuel briquet from southern pine sawdust at a moderate cost. These briquets have been shown to possess many qualities which should make them desirable as a low-ash, free-burning fuel for domestic purposes, and as a substitute for cordwood. In the process the sawdust is preheated to destroy the elasticity of the wood and to eliminate moisture and combined oxygen and hydrogen. The weight is thus decreased about one-third and the heating value per pound almost doubled. The preheated sawdust is then moistened and briquetted hot without the addition of a binder.

A Practical Method for the Selection of Foundations Based on Fundamental Research in Soil Mechanics, W S Housel (Michigan University [Ann Arbor], Engineering Research Bulletin 13 [1929], pp 117, pls 2, figs 44).—This bulletin presents a method for determining the bearing capacity of foundations for spread footings in a cohesive and plastic material which is based on a fundamental analysis of the problem. While the theory presented may be fundamental, and thus general for all types of cohesive material supporting data from extensive tests are presented only for that type of material that is usually classified as a plastic solid.

It was found that the physical properties which govern the bearing capacity of a cohesive or plastic soil such as clay may be determined by a comparatively simple test procedure. It appears that bearing-capacity tests properly analyzed yield the necessary data for the design of substructures, such as spread footings, and furnish an accurate and practical method for the solution of such problems.

The procedure is divided into several steps. The first step consists of bearing-capacity tests on two or more bearing areas differing in size. The second is the determination of two factors of bearing capacity by straight-line equations resulting from the analysis of the load-settlement diagrams for varying amounts of settlement. The third step is the determination of two physical characteristic coefficients from the relations shown by a general equation for bearing capacity, and the fourth is the selection of the bearing-capacity limit and the allowable bearing capacity from the curve of physical characteristics. The final step is the determination of the allowable bearing capacity of any size of spread footing for the desired settlement by graphical solution of the general equation.

In the tests, the bearing capacity of soil was found to be dependent upon two separate and measurable factors, defined as perimeter shear and strength of the pressure bulb, and the straight-line relation of bearing capacity to the relative size of bearing area was formulated for equal amounts of settlement. The general relation also was established between settlement, bearing capacity, and the size and shape of bearing areas, which is independent of the time element.

The theory of pressure distribution on bearing areas was developed and checked experimentally, which is quite contrary to some accepted conceptions of pressure distribution and which indicates the advisability of revising the present methods used in the design of footings.

The experimental data from an extensive investigation to determine the physical characteristics of a plastic soil also are presented in complete form. In this connection an appendix is included on the development of the physical characteristics ratio which is an attempt to furnish a more complete interpretation of the physical-characteristics coefficients, by developing relations between these quantities and the laws of elastic solids and viscous liquids.

Book Review

"Farm and Village Housing" is the title of the seventh in the list of publications containing final reports of committees of the President's Conference on Home Building and Home Ownership, and presents the results of the study of the Committee on Farm and Village Housing of that conference. This first volume in the field of rural housing in America is a valuable contribution to the literature on that subject and will be useful as a reference work. It is divided into six main parts, including farm and village housing conditions, design and construction, farmstead planning and beautification and painting, economic and financial aspects, some special phases and problems of farm and village housing, and educational aspects. Under these various groupings are included a study of farm and village houses in the United States, housing conditions and problems in part-time farming, a brief history of rural architecture in the United States, suggested standards for farmhouses, planning the farm house, practical suggestions on farm house construction, the house for the growing income, farmstead planning and beautification, financing of house building and improvements, the relation of taxation to housing, insurance of dwellings, a recommended program of research and education on farm and village housing, and a list of references on rural housing. The book is published by The President's Conference on Home Building and Home Ownership, New Commerce Building, Washington, D. C. The price is $1.15, postage prepaid.

"Report of the Chief of the Bureau of Agricultural Engineering" (U. S. Department of Agriculture, Washington) is the title of the official account of the Bureau's first year from July 1, 1931, to June 30, 1932. It is a 22-page booklet with subtitles and paragraph headings as follows: **Irrigation Investigations**—Duty of Water, Pumping for Irrigation, Reclamation of Alkali Land, Design and Invention of Apparatus, Silt in Streams and Reservoirs of Texas, Flow of Water in Irrigation Conduits, Underground Storage of Water, Sewage Irrigation, Control of Gravel in Open Channels, Irrigation Customs, Regulations and Laws; **Drainage Investigations**—Run-off and Ditch Capacities, Hydraulic Experiments at the University of Iowa, Durability of Draintile, Maintenance of Drainage Ditches, Drainage-District Operation, Operation of Drainage Pumping Plants, Drainage of Sugar Cane Lands, Control of Ground Water in Peat and Muck Soils, Soil-Erosion Control; **Farm-Land Development; Farm Machinery Investigations**—Corn-Borer Control, Mechanical Distribution of Fertilizers, Sugar Beet Machinery, Cotton-Production Machinery, Corn-Production Machinery, Power and Machinery on Farms, Spraying and Dusting Machinery, Pink-Bollworm Control, Grasshopper Control, Artificial Drying of Crops, Ginning of Cotton; **Farm Structures**—Improvement of Farm Homes, Farm-Building Construction, Dairy Stable Temperatures, Storage of Perishable Products; **Extension Work;** and **Service Work.**

"Low-Cost Fireproof Concrete Homes" is the title of a new booklet of suggestions for design and construction of small houses estimated to cost from $2,700 to $6,600, exclusive of the lot and financing charges, just published by the Portland Cement Association, 33 West Grand Ave., Chicago, Ill., to meet the demand, which has been paramount since The President's Conference on Home Building and Home Ownership, for facts about the building industry's work to effect dollars-and-cents reductions in home-building costs. Estimated construction costs for the 17 suggested designs in the booklet average about $4,000, with several costing less than $3,000.

AGRICULTURAL ENGINEERING

Established 1920

A journal devoted to the advancement of the theory and practice of engineering as applied to agriculture and of the allied arts and sciences. Published monthly by the American Society of Agricultural Engineers, under the direction of the Publications Committee.

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Contributions of interest and value, especially on new developments in the field of agricultural engineering, are invited for publication in this journal. Its columns are open for discussions on all phases of agricultural engineering. Communications on subjects of timely interest to agricultural engineers, or comments on the contents of this journal or the activities of the Society, are also welcome.

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Raymond Olney, Editor

R. A. Palmer, Associate Editor

Subsidy and Technical Aid

IN A popular hindsight exposition of federal farm follies and foibles Garet Garrett has concluded with the observation that ". . . . . . what now overtakes agriculture, to everybody's dislike, is the common fate of a subsidized industry."[1]

There is a proposition for consideration by those who will agitate further political farm relief.

Mr. Garrett also remarks, with implied censure of the U. S. Department of Agriculture's research and extension activities, that ". . . . . in other ways the government has been acting to intensify (agricultural) competition. For twenty-five years it has been promoting and extending agriculture by every means it could think of, and stressing always the commercial side of it. Agriculture as business. Agriculture as industry. Low cost production. Profit."

On this point we rise to question: Have those activities been so extremely unwise, the ones by which the research and extension forces of the U.S.D.A. have been effective in promoting and extending agriculture? Was not commercial agriculture a logical ideal, early in those twenty-five years, when our farm product export market was continually expanding? Whatever else it might be, was not agriculture first of all a business when winning the World War was our prime problem? Was attention to lowering the cost of farm production responsible for disastrous post-war speculation in farm land? Was agriculture as industry unreasonable in 1928 when few, if any, foresaw a setback in industrial expansion? Is low-cost production to be decried today when there is hunger enough without high food prices? Would government-advocated subsistence farming create a rural buying power sufficient to prevent, or even to cushion, the effect of a major economic depression?

The economics of depression are easily clouded by emotionalism. We invite attention to the distinction between subsidy and technical aid. Subsidies encourage the poorly qualified to continue efforts in their ill-chosen fields; discourage economic self-improvement; cultivate the-world-owes-me-a-living attitude; hamper adjustment to changing conditions; and promote excessive competition. Technical aid is most used by those who have the best qualifications for farming. They use it to further improve their qualifications. It does not stimulate an unhealthy degree of competition.

More power to the U.S.D.A. efforts to lower farm production costs! Less misappropriation of funds to effect subsidies!

[1]"Notes of These Times—The Farmer" by Garet Garrett, "The Saturday Evening Post," November 19, 1932.

Toward Farm Profits

NECESSITY is mothering not only inventions in the strict sense of the word, but the widespread farm application of some important principles of low-cost production.

The economics of large-scale operation, of mass production, have experienced a temporary setback in popular esteem and applicability.

But the economics of individual practice, of specific operations, of small combinations of operations, of low-cost small-scale production, are being highly developed. Farmers are showing a growing interest in conservation of their soils; in producing large crops on small acreages at low unit cost with low labor peaks and with high load factors on their equipment. They are earnestly applying agricultural engineering recommendations along these lines.

And well may agricultural engineers and farmers continue their fight to lower farm production costs. What their efforts mean, not only to themselves, but to the whole country, is explained in the October issue of the National City Bank Letter, conservative monthly exponent of the economic principles involved in business situations. It says ". . . . . This stop in the advance of farm prices adds weight to the warning uttered in this Letter a month ago, when it was stated that a rise in raw material prices sufficient to close the gap between what the farmer sells and what he buys was not anticipated, and that 'it will be necessary to keep on closing it through reduction of costs if recovery is not to be greatly delayed.'"

Cooperation Wanted

THE A.S.A.E. has a Committee on Row-Crop Management. It has been conducting a nation-wide survey of row widths and of shovel equipment used in cultivating row crops. The manufacturers and the agricultural engineers of the state colleges have, for the most part, cooperated generously in supplying the necessary information. Eleven colleges remain to be heard from.

R. I. Shawl, chairman of the Committee, recognizes the well-known general antipathy to answering questionnaires. But should this stand in the way when the end justifies the means? The end in this case is information which may reasonably be expected to result in manufacturing economies and in lower cost and more effective practices for farmers raising row crops.

Mr. Shawl grants that it might easily take one a half day to fill out the committee's questionnaire. Most of those approached have agreed that the information sought would be well worth the cost of assembling it, to all concerned. The Committee wishes to present a complete report at the Society's annual meeting in June; to make the complete information available for study and whatever action it may indicate, without further delay. Those who may have received the questionnaire and failed to answer it previously, will be making a big contribution to agriculture and to the agricultural-engineering profession by furnishing the desired information without further delay.

An Achievement

IN "ANTIOCH NEWS"[1] we read that ". . . . . . social health will not be a discovery but an achievement."

And the author of that statement might well have added economic welfare in general and agricultural prosperity in particular.

[1]Vol 10, No 3 (Oct 15, 1932). Antioch College, Yellow Springs, Ohio.

A.S.A.E. and Related Activities

Technical Division Meetings Reflect Progress

ATTENDANCE and attention at the meetings of the A.S.A.E. technical divisions at Chicago, November 28, 29, and 30, reflected no depression in interest, thought, and mental progress along agricultural-engineering lines.

In the characteristic A.S.A.E. meeting atmosphere of genial good nature, renewed friendships, and intelligent interest in each other's agricultural-engineering activities, the men spent many hours together exchanging ideas and information. Broad and genuine interest was shown in the programs of both the Power and Machinery Division and the Structures Division. The meetings adhered closely to the programs announced. The Stevens Hotel provided its South and West Ballrooms for the scheduled sessions, the same as last year.

Registrations for the first day numbered more than one hundred. Late comers brought the total up close to 150. Some failed to register. The attendance compared favorably with that of the corresponding meetings every previous year.

Farm trade up to four billion dollars awaits only a corresponding increase in buying power on the part of American farmers, Harry R. O'Brien, agricultural writer, told the Structures Division in an address on "Industrial Decentralization and Rural Housing Problems." This and other observations of his were the fruit of more than one thousand miles of travel through farming areas and of recent direct contact with many farmers and their wives. He pictured the forced movement of many urban people to farms, due to unemployment; suggested possible implications of the trend; and indicated an obligation and opportunity for agricultural engineers to help these people, as well as established farmers, make the best of their necessary adjustment to new conditions. This feature of the program attracted the attention of many more than the nucleus of members interested in technical farm structures problems.

A report of the Committee on Coordination of Building Plans revealed that its work is progressing slowly, due to the necessity and difficulty of carrying it on by correspondence. It is, however, being continued in view of the apparent high value of the results.

Irked by the currently popular condemnations of engineering activities in general, members of the Structures Division spent considerable time discussing the social and economic effects of their activities, and their opportunities to aid in the present period of readjustment.

In the Power and Machinery Division the same circumstance was dealt with in Arnold P. Yerkes' paper on "Some Economic Aspects of Farm Mechanization," which was followed by several prepared discussions. Leonard J. Fletcher urged that all agricultural engineers take every opportunity to refute misstatements and to spread true information on the economic and social values of agricultural-engineering activity.

An extra feature of the Power and Machinery Division Session on Tuesday was a talk by C. A. Cobb, editor of the "Southern Ruralist," who was introduced by L. J. Fletcher, agricultural engineer, Caterpillar Tractor Co. Mr. Cobb expressed sympathy with the activities of agricultural engineers in helping farmers and farmers' wives to find time to devote to duties and purposes above those necessary to bare existence. He indicated that everything should be welcomed which helps increase income from human effort expended. He further indicated a firm belief that American cotton growers, and other farmers as well, need not fear foreign competition if they will keep on improving their methods and equipment.

Forage drying, combining, hay and straw handling, valve problems and economics all proved to be popular subjects with the farm machinery men. Most prominent in their minds, however, was the pneumatic tire for farm tractors. With the advantage of novelty and some lively differences of opinion, with strong claims made for it, with samples on exhibit in three corners of the room, and with nearly a half day on the program, the pneumatic tire easily commanded the greatest volume of discussion. It rolled into the place of controversy occupied a few years ago by the combine "east of the Rockies" and previously by other developments of auspicious sponsorship but uncertain future.

Acting for and in the absence of W. M. Hurst, chairman of the Committee on Hay and Forage Crop Drying, Dr. L. M. Kishlar called a meeting of those interested in that subject. Three suggestions of additional work for the committee were offered, namely (1) that it give consideration to cotton drying problems; (2) that it try to determine the moisture content of alfalfa at which leaf shattering begins; and (3) that it also try to determine the maximum moisture content of alfalfa for safe storage.

The Committee on Agricultural Engine Research, chairmanned by R. B. Gray, took definite action on the classification of oil viscosities by the S.A.E. number system. It passed a motion to the effect that a resolution be prepared recommending that the A.S.A.E. adopt or approve as standard the S.A.E. viscosity number system for crankcase, transmission and differential lubricants; that this resolution be submitted to the tractor industry for comments; and that if generally approved, it be submitted to the A.S.A.E. Standards Committee for action.

C. G. Krieger, vice-chairman of the Committee, made a progress report on the committee's tests of compromise or dual type tractor engines adapted for operation on gasoline only, with a view to determining the effect of the change on power and efficiency. Other subjects discussed were gasoline tax laws, and possibilities of non-petroleum fuels. Several engineers present indicated personal belief that the Committee is working in the right direction.

Mr. Gray also acted for M. L. Nichols, chairman of the Committee on Soil Dynamics, in calling a meeting of those interested in the subject. Discussion ran mostly to plow point and moldboard materials. John P. Seaholm, experimental engineer for the Minneapolis-Moline Power Implement Company, pointed out that farmers are wasting a lot of money in buying soft-center steel shares, due to the fact that blacksmiths fail to harden them correctly after sharpening. He urged that manufacturers make a united effort to encourage the use of the less expensive solid steel shares by all farmers except in the few soils where soft-center shares will actually overcome scouring difficulties. Representatives of several alloy-steel manufacturers were present and assured their willingness to cooperate in attempts to improve plow metals.

R. I. Shawl's Committee on Row-Crop Management decided to complete its survey of row-crop widths and of cultivating shovel equipment in current use in various parts of the country. It plans to be ready to report its results at the annual meeting of the Society in June. Other matters discussed by the committee were rubber tire equipment for row-crop tractors, standardization of cultivator shovels, and the possibilities of encouraging the practice of drilling corn.

D. A. Milligan called together the Committee on Tractor Drawbar Investigations and reported progress in its work leading toward the ultimate

standardization of certain features of drawbar design and location.

C. E. Seitz, president of the American Society of Agricultural Engineers, took occasion to announce that the Society is in a sound financial position. He urged the members to work on getting new members, especially from among the engineers in commercial work. He also urged them to spread information on the value of advertising in AGRICULTURAL ENGINEERING and pointed out the need of increased income to carry the Society's publication and other headquarters work. President Seitz closed his remarks with the announcement that the Meetings Committee has given definite shape to the program for the Society's annual meeting at Purdue University in June 1933. The general sessions of that meeting are to emphasize the social aspects of agricultural engineering.

Wednesday morning found a majority of those present for the power and Machinery Division meeting still on hand and interested in the round table session on "The General-Purpose Agricultural Tractors." During the forenoon Chairman W. L. Zink called on research men from the colleges who reported on their experiences with and views on general-purpose tractors.

A few power farmers were present and joined in the discussion during the afternoon, but the engineers of the manufacturers were for the most part in a listening mood. The subject proved too broad to cover in the time available, and there was some difficulty in agreeing on the most logical point of attack. The suggestion which seemed to meet with strongest approval was made by Col. O. B. Zimmerman of the International Harvester Company and supported by G. D. Jones of the Cleveland Tractor Company. It was to the effect that the general-purpose tractor men should make closer contact with M. L. Nichols, John A. Slipher and agronomists working along similar lines, to get more basic information on the job to be done by the general-purpose tractor and its implements in tillage. It was proposed that some papers along this line be included in the program for the annual meeting. The discussion continued on its own strength throughout the afternoon and into the evening.

Pacific Coast Section Meets January 20

THE next meeting of the Pacific Coast Section of the American Society of Agricultural Engineers, which will be held at San Jose, California, on January 20, is the eleventh yearly meeting of that Section. A very interesting program is being arranged and will deal with such important subjects as the practical application of electricity in soil heating, the design and application of machinery and equipment for applying insecticides, prevention of accidents in agriculture, and precooling of fruit and vegetables for eastern shipment.

During the luncheon period a business meeting of the Section will be held, at which the election of officers will take place. A dinner with a speaker and entertainment is being planned for the evening.

President Seitz Speaks Over Radio

TWICE recently President Chas. E. Seitz of the American Society of Agricultural Engineers has addressed radio audiences on questions of interest to agricultural engineers. On October 8 he addressed the meeting of the North Atlantic Section of the Society at Albany, N. Y., on the purpose and scope of the Society, and his address was broadcast from Station WGY of the General Electric Company.

On November 29 he contributed to a Virginia program put on the air by Station WJJD of Chicago, the subject of his address being "The Use of Power in Agriculture."

Mr. Seitz is professor and head of the agricultural engineering department of Virginia Polytechnic Institute at Blacksburg.

Southern Section at New Orleans

AGRICULTURAL engineers who can do so, will find it well worth while to attend the meeting of the American Society of Agricultural Engineers, to be held at New Orleans, February 1, 2, and 3, in connection with the annual meeting of Association of Southern Agricultural Workers.

An account of the plan and subjects to be featured at this meeting appeared in the November number of AGRICULTURAL ENGINEERING (pages 298 and 299). Watch the January number for a program of the meeting in its final form.

Unusual interest attaches to this meeting, especially for members of this Section, inasmuch as the Council of the Society recently voted to recommend to the new Council—which will take office at the close of the next annual meeting in June—that the invitation of the Southern Section to hold the 1935 annual meeting of the Society at Athens, Georgia, be accepted. This group of members will therefore have much to discuss at New Orleans in anticipation of the Section acting as host to the Society as a whole when it meets in "Dixie" in June, 1935.

ASAE Personals

H. J. Barre, J. B. Davidson, and **Henry Giese,** agricultural engineers, are joint authors of Bulletin 109, entitled "The Durability of Prepared Rural Roofing," recently issued by the Iowa Engineering Experiment Station, Ames, Iowa.

Frank N. G. Kranick, of the J. I. Case Company, will address the state farm implement dealers' associations of both Indiana and Michigan during the month of December. His talks will deal with the reasons why farm mechanization will prevent the menace of foreign agricultural competition to American farmers.

F. E. Price, agricultural engineer, Oregon Agricultural Experiment Station, is one of the authors of three bulletins—Bulletin 301, entitled "Design of Equipment and Method for Preparing Starter for Oregon Creameries and Cheese Factories"; Bulletin 305, entitled "Cream Refrigeration on the Farm and the Quality of Butter Manufactured," and Bulletin 307, entitled "Electric Hotbeds and Propagating Beds"—recently issued by that institution.

Walter W. Weir, associate drainage engineer, California Agricultural Experiment Station, is author of Bulletin 538, entitled "Soil Erosion in California: Its Prevention and Control," recently issued by that institution.

New ASAE Members

Andres P. Aglibut, instructor in the departments of agricultural engineering and agricultural education, College of Agriculture, University of the Philippines. (Mail) Agricultural College, Laguna, P. I.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the November issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Henry A. Magnuson, assistant architectural engineer, Division of Plans and Service, Bureau of Agricultural Engineering, U. S. Department of Agriculture, Washington, D. C. (Mail) Apt. 111, 1620 Fuller St., N.W.

Wm. B. Nivison, graduate assistant in agricultural engineering, University of Minnesota, University Farm, St. Paul, Minn.

Geo. B. Nutt, associate professor of agricultural engineering, Clemson College, Clemson College, S. C.

Hugh D. Sexton, graduate assistant, agricultural engineering department, Alabama Polytechnic Institute, Auburn, Ala. (Mail) 151 N. College St.

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